SCHOOL SCIENCE AND MATHEMATICS

VOL. VI. No. 3 CHICAGO, MARCH, 1906 WHOLE No. 41

NEW THEORIES OF MATTER IN RELATION TO CHEMICAL AND PHYSICAL THEORY.

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[CONTINUED FROM THE FEBRUARY NUMBER.]

There are at present five radio-active elements known. These are in the order of their discovery, uranium, thorium, radium, polonium and actinium. The radiations from these elements are in general alike, yet they vary in kind and greatly in intensity. As an example of the former there are three types of radiation, known as the A (Alpha), B (Beta) and G (Gamma) rays. Of these uranium gives off A and B rays; thorium, all three; radium, all three; and polonium, A only. With reference to variation in intensity the spinathariscopes of Sir William Crookes contain radium salts whose activity may reach 300,000 or more compared with that of uranium.

Briefly, the characteristics of the A, B and G radiations are as follows:

The A-rays are corpuscles approximately equal to the mass of the hydrogen atom and travel by radial expulsion with the colossal velocity of 20,000 miles per second. They have little or no penetrating power and can be stopped readily by a sheet of paper. They are deviated by an electromagnet. The direction of the deviation indicates that they carry positive charges.

The B-rays are corpuscles, they are identical in type to the cathode rays of a Crookes tube, and have a mass of about 1-1000 that of an hydrogen atom. They travel by radial expulsion with a speed which at times may approach that of light. Because of their small size and high speed they have a greater penetrating

power than the A-rays. They carry negative charges and are readily deviated by an electromagnet but in a direction opposite to that of the A particle.

The G-rays are *not* deviated by a magnet. They have, however, great penetrating power,—readily passing through 10 centimeters of lead. They are much less numerous than the two former types of rays. It is quite likely that the G-ray stands in a similar relation to the B-ray as the X-ray stands to the cathode ray, being produced like the X-ray by sudden acceleration, or, to express it more clearly, the X-ray is the tremor set up in the ether by the sudden stopping of the cathode corpuscle when it strikes the walls of the tube or the platinum target, while the G-ray is the tremor in the ether caused by the sudden acceleration of the B-corpuscle when it leaves the atom or mass of which it was originally a part.

Of the three types the A-rays are the most and the G-rays the least important. The B-rays are the most active on the plate.

We see from the above that in the types A and B we have rays that correspond to Newton's corpuscular theory of light.

Another property that is in general a characteristic of radioactive elements is that they give off an emanation. Uranium seems to be an exception. This emanation, first observed by Rutherford, is a gas spontaneously given off to a more or less extent at all temperatures and pressures, and as any other gas thus evolved diffuses through the air and finally permeates the entire space within the vessel. The emanations from some of the active elements in turn give off A, B and G-rays, having aside from the characteristic properties of these rays, a period of decay different for each substance and also for each stage. For instance radium, so far as known, undergoes six changes before the final inactive product is reached. They are radium emanation, emanation X (first change), emanation X (second change), third change, fourth change, and final product. The period of decay, that is, the time taken for half of the body to undergo change, varies as follows: 3 days in case of radium emanation, about 3 minutes in emanation X (first change), 30 minutes in the second change, 28 minutes in the third change and 200 years in the fourth change. This last value is more or less speculative.

The above is sufficient to refresh our memories and to call to mind the possible significance of these discoveries. The success-

ive changes that the emanations from the various radio-active substances undergo are significant. By a train of reasoning based upon numerous experiments Prof. Rutherford and Mr. Soddy suggested that helium might be an ulitmate product of radio-active change. The honor of showing that radium does produce helium is due to Sir William Ramsay and Mr. Soddy.

Scientists agree that this is one of the most important chemical results ever attained in chemical science. Here we have the first recorded instance of the transmutation of the elements, revealed by one of the most approved methods of investigation known to science—spectrum analysis. The alchemist's dream is realized!—only that we are not producing gold from silver, but are observing the transmutation of radium into helium.

Radio-activity reveals in itself, that the atom is of very complex structure, and that the A, B and G-rays result from explosions in which one or more B particles are expelled. It also leads us to believe that the energy is within and not without the atom. The energy that we have to deal with in our every day experience is as nothing compared to that stored up in the atom.

The energy which one pound of radium possesses is perhaps millions of times greater than the energy which is set free in any known chemical change in an equal quantity of matter. It is impossible for us to conceive of the B particle being driven away from the atom at the enormous speed of light by the mere force of repulsion alone. The hypothesis that an atom consists of a sort of self-contained solar system, having negatively charged corpuscles within, balanced by atom partic'es, seems to account reasonably well for the elements.

We have strong evidence that such is the construction of the atom, yet further proof is necessary before it will be accepted as a fact. "Up till now the sheet anchor of the chemist has been the atom." The atom has been proven to be complex in the case of a very few elements, and these are elements of high atomic weights.

Radio-active experiments show that the atom has a long life. That of radium is approximately 1,100 years. No doubt there are other elements whose atoms disintegrate even more slowly. Radio-active substances are disappearing. This is suggestive that all matter is changing. That there is a parent substance. In the case of radium it is thought by some to be uranium; however, experiments that have been performed just recently show that

radium is not the direct product of uranium—there may be several intermediate steps that have as yet not been recognized.

We have seen that the B particle, or corpuscle, is negatively charged, and of mass 1-1000 that of the hydrogen atom, and that the system with which this negative corpuscle is at first associated has a positive charge and is atomic in size. A possible view, based upon the above, is that *matter* is *electricity*. In this connection, I quote the following from a recent article by Prof. E. L. Nichols: "Lodge in a recent article in which he attempts to voice in a popular way the views of this school of thought, says: 'Electricity under strain constitutes charge: electricity in motion constitutes light. What electricity itself is we do not know, but it may, perhaps, be a form or aspect of matter * * *. Now we can go one step further and say, matter is composed of electricity and of nothing else—' ".

"If for the word *electricity* in this quotation from Lodge, we substitute ether, we have a statement which conforms quite as well to the accepted theories of light and electricity as his original statement does to the newer ideas it is intended to express. This reconstructed statement would read as follows: *Ether* under strain constitutes charge; ether in locomotion constitutes current and magnetism; ether in vibration constitutes light. What ether itself is, we do not know, but it may, perhaps, be a form or aspect of matter. Now we can go one step further and say: Matter is composed of ether and nothing else."

This is the view of Kelvin and Helmholtz, referred to earlier in this paper. It seems to me that this interpretation bids fair to clear away much of the mystery that at the present day encompasses the conception of matter, ether and electricity.

In line with this thought, Prof. Nichols continues, "—if matter be regarded as a product of certain operations performed upon the ether, there is no theoretical difficulty about transmutation of elements, variation of mass or even the complete disappearance or creation of matter." It verily seems that our fundamental law, the conservation of matter, is not only threatened but in actual need of revision.

As additional evidence on the electrical theory of matter I quote from an article read before the British Association by the Hon. A. J. Balfour. He says, "—to-day there are those who regard gross matter of every day experience, as the mere appearance of which electricity is the physical basis: who think that

the elementary atom of the chemist, itself far beyond the limits of direct perception, is but a connected system of monads or sub-atoms which are not electrified matter but are electricity itself; that these systems differ in the number of monads they contain in their arrangement, and in their motion relative to each other and to the ether; that on these differences, and on these differences alone, depend the various qualities of what have heretofore been regarded as invisible and elementary atoms; and that while in most cases these atomic systems may maintain their equilibrium for periods which compared with such astronomical processes as cooling of a sun, may seem almost eternal, they are not less obedient to the law of change than the everlasting heavens themselves.

"If gross matter be a grouping of atoms, and if atoms be a system of electrical monads, *what are these monads?* It may be as Prof. Larmor has suggested, they are but a modification of the universal ether, a modification roughly comparable to a knot in a medium which is inextensible, incompressible and continuous. But whether this final unification be accepted or not, it is certain that the monads cannot be considered apart from the ether. It is on their interaction with the ether that their qualities depend—and without the ether an electric *theory* of matter is impossible."

This is a great revolution in scientific thought. Two centuries ago electricity seemed but a toy. Now according to the electrical theory it is matter itself.

Less than a century ago the ether was just firmly established. "To-day it is the stuff out of which the universe is wholly built."

Under the old theory mass was thought to be an inherent original property of matter, unchangeable, constant, and unalterably identified with each material fragment through chemical or physical conditions. Now mass can be, or possibly is explained. It is due to the relation between the electrical corpuscle, which itself is a state of the ether, and the ether. And hence mass is not unchangeable—but changes as the velocity of this corpuscle changes

It is well in our discussion of a topic in which there seems to be so much of promise, yet the future of which is mostly a matter of speculation, to stop and listen to contrary views. The following will help to stay our ardor and make us more conservative, for we have seen that, in the past, some of our theories have had their day.

"—It appears from day to day more plainly that radio-activity

seems to be extremely widely distributed, and this observation leads us to the question whether radio-activity may not be simply a purely physical phenomenon, which may be exhibited by matter without in any way modifying its chemical nature, comparable to the megnetism of megnetic iron ore, which, like radio-activity, may be intensified, transformed, apparently destroyed, and again called forth, and which at the same time also represents a mysterious manifestation of energy, without leading anyone for a moment to imagine the existence of another element in magnetic ferro-ferric oxide not existing in the magnetic iron oxide."

He adds, "that the idea of an elemental difference was not thought of by anyone when first magnetic alloys were successfully made from non-magnetic metals, such as manganese, tin, antimony, and aluminum.

"That considering the 'radium craze' now afflicting the world, and especially non-scientific circles, there is something humiliating to chemists to find that six years after the discovery of radium they can say no more than that it cannot be distinguished from barium except by its higher atomic weight and its remarkable radiation."

The above view is taken from a remarkable critical article by the late Clemens Winkler on Radio-Activity and Matter, which constitutes an earnest warning expressing the judgment of one of Germany's greatest chemists. It is a word of warning that should be heeded. Whether radio-activity is physical or chemical in its nature may still be a mooted question. The evidence that has been thrust upon us by the newer school points seemingly with great positiveness to the latter view.

The ultimate disintegration products, of the radio-active elements, as set forth by recent experiments, may include lead, bismuth, barium, the rare earths, hydrogen, helium and argon. The process of decomposition is slow. We infer this from the estimated life of the radium atom, which we remember is about 1,100 years. This means that the expulsion of B-corpuscles takes place at comparatively long intervals, and radium is the most active of all. In the case then of allied metals the expulsion may take place at extremely long intervals, measured by years or even centuries. Hence, we may conclude that the apparent absence of radio-activity does not imply that those elements have not figured in the evolution of matter. Do we infer, then, that the

quantities of lead, bismuth, barium, etc., already existing have been produced wholly by the disintegration of the heavier elements? Science, as yet, has not a positive answer. However, at the present vigorous rate of investigation the world over an answer will soon be forthcoming.

LOCAL MATERIAL FOR ZOOLOGICAL WORK.

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One misfortune in zoology teaching in the United States is the fact that so many of the best text books for secondary schools were written at some marine laboratory. Phyla, like the Echinodermata and Coelenterata, are apt to receive a disproportionate amount of attention. Dr. Davenport's admirable elementary book, written at Cold Springs Harbor five years ago, represents this type of texts. Without littoral specimens, the teachers of the interior must be of the exceptional kind to maintain interest in handling these books. The best that can be done is to buy types, for many school boards are averse to purchasing sponges, hydroids, starfishes, etc., every year for individual study. And even a dissertation by the teacher on these selected marine types may be informational but hardly inspirational.

Why must all the branches of animals be covered in an inland laboratory? True, the sponge and jellyfish groups have their allies in almost every fresh water stream, but it is also beyond question that these creek forms are not the best pedagogically to present to a beginning class. But where half a year or less can be devoted to the subject, little more than a few prepared sections of these animals can be given.

Zoology teaching in this country is more or less unduly influenced by the research spirit of Germany. Many of us attempt to make plain with Haeckel how phylogenesis is the directive force of the ontogenetic development of an organism. A boy cannot see anything of zoological dignity, unless he is armed with a microtome or one-sixth objective, or he is not saturated with the real spirit, if he is slow in rolling forth something of the pompous terminology of the Rhine.

Happily, a re-adjustment is coming; it is born of the great

countervailing force that arises from below. The Nature Study movements of the grades are combating the research ideas from above and better results are in the horizon. Is it good to hold out in clear relief such a motive as the training of the perceptive powers of the child in the grades? Can there not be a logical continuation of it in the High School and College? And if this be one of the chief purposes of the study, then the school boards need not buy a cent's worth of material to run the best laboratory, excepting, of course, a few reagents, a compound-microscope, etc.

The farmers of Pennsylvania today are fighting a battle with the San Jose scale whose depredations, if they lose, will foot up into the millions. Here is a species of louse unfortunately present in every county, while not showing radial symmetry like the sea-urchin nor the the diploblastic structure of the hydroid, it has nevertheless many points of real interest aside from its economic features.

Why have the students study an account of the starfish in its relation to the oyster industry more thoroughly than the practical effects of various washes on our fruit tree pests?

A defensible course in zoology for our inland schools covering one year's work can be given without going five miles from the building for material. Such a work as Jordan's Animal Life used in connection with recitations based on the exercises in the laboratory will give the average student sufficient data on modern biological problems, and will help him the better to interpret the facts of life and structure before him. Unless the teacher arouses interest in the local fauna, his value to the student is inconsiderable. If the unaided eye is not made to go to the limit of its power in common things, the eye assisted by a sub-stage condenser, a camera lucida, and other biologic paraphernalia, will be impaired in its future usefulness.

THE WORK OF THE HYDROGRAPHIC OFFICE IN ITS RELATION TO COMMERCE.

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[CONTINUED FROM THE FEBRUARY NUMBER.]

It will thus be seen that the policy of the Hydrographic Office is co-operative in its action. Each captain makes his report to the main or one of the branch offices. These reports are corrected, checked by other reports and immediately published and sent to shipmasters and navigators all over the world free of cost. In other words, instead of the captain having to seek for information, the printed notices and other information seek the captain.

There is an essential difference between a map and a chart, which consists in the fact that the one begins where the other ceases. A map, which is familiar to everybody, consists in a delineation of the prominent topographical features of the land, rivers, mountains, hills, railroads, cities and other details for the guidance of the land traveler. All this is of little consequence to the navigator. The only cities he can use are the seaports; the only rivers are the mouths of navigable streams; the only hills are those sufficiently near the coast to assist him in taking bearings for his navigation and surveying. The exact position of the coast line found in navigable waters is, however, of vital importance, as he runs by his log and elapsed time, and if a coast charted is further out than it is shown on the chart, he is liable to reach it sooner than he expected to do from his calculations, and if he should be enveloped in a fog about the time he is nearing this coast, he would meet with a disaster which would mean endangering the lives and property that are in his charge.

The varying depths of water near the coast (which means the configuration of the bottom) is also of vital importance for the same reason; and you will notice on the chart of Lake Michigan shown you that this depth is marked by a multitude of figures, which show, with reasonable exactness, exactly how much water lies between him and the earth beneath, which he must be careful to prevent his vessel from striking. Every one of these figures means that the depth of the water has been carefully measured at that spot, and its position located on the chart by bearings of

prominent objects on shore. You will also notice a number of fine dots and dashes in the water in close proximity to the shore; this means shallow water, and is a danger signal to the navigator. Outside of these dots, you will notice a continuous line, varying irregularly from the shore, and made up of dots and dashes. This is known as the 20 fathom curve, or the line making 120 feet depth of water, and a careful navigator when nearing it will get his lead line out, and keep it going until he enters his harbor and is moored to the wharf, or comes to anchor. You will also notice this curve line defining outlines of irregular shape at various points in the water away from the land. These mean shoals, or elevations of the bottom, which may, or may not be dangerous, according to the depth of water marked upon them, and the amount of water needed by the vessel for safe navigation.

This safe distance from the bottom of the vessel to the earth under it is a varying factor, depending upon the locality, the tides and the weather. In the vicinity of the Bay of Fundy the tide rises some forty feet. If a ship drawing thirty feet was to pass over a spot that sounded at low tide the skipper would need ten feet more than the draft of the vessel in passing over the soundings given in calm weather, but if a violent storm were blowing, so that the vessel would rise forty or fifty feet with the run of the waves, he would need seventy feet to avoid striking the bottom with a crash which would destroy his ship. On the other hand if the tide was high and the weather favorable, he would have a margin of forty feet more than the figures shown by the soundings.

The height of the tide varies with the localities and the configuration of the coast; thus while it is forty feet at the Bay of Fundy, it is four and five-tenths (4.5) feet at New York, and here on the lakes it is nothing. Thus it will be seen that the shape of the land under the water, and its correct delineation on the chart, are of vital importance to the navigator. This is why the chart has been aptly defined as "Submarine geography," and why all these depths, called "soundings," are engraved with such care and accuracy on the charts.

The shape of the bottom changes from year to year, as storms create currents which wash the loose sand into various localities, much as the wind drifts snow over a prairie, and the consequence is, that these soundings and surveys must be made continuously. Every careful captain makes it a religious duty to buy a new edition of each chart as fast as it is published, and to destroy his old

one immediately, in order that it may not be used for navigation after it has been pronounced defective by the Government. As an instance of the importance of this may be mentioned the fact that a few years ago a shoal of 18 feet had formed during the winter months at the upper end of Lake Michigan off Waugoshance lighthouse, directly in the established channel. A captain on a vessel drawing eighteen and one-half feet of water touched bottom. This was reported to one of the branch offices, a notice issued, and later the chart covering that vicinity corrected. After the chart had been corrected, and had been issued to the public, another steamer came along, drawing some nineteen feet of water, and being navigated by an old chart struck this shoal, where the captain's chart showed a safe passage. The grounding resulted in about $30,000 damage to the vessel, besides placing her out of commission for some months, so that the owner lost the earning power of his vessel for a considerable part of the season, in addition to the amount paid for repairs. A very indignant protest was made to the government by the owners; but the Navy Department promptly showed the owner that a new chart had been issued with the shoal correctly marked sometime before the vessel struck, and that any culpability should attach to the company, which did not insist that its vessels be supplied with the latest charts. It is needless to say that no vessel of the fleet has since been operated without keeping all its charts up to date.

The re-engraving of these charts is expensive, and the Hydrographic Office is frequently without money to furnish new ones; so it has adopted the weekly "Notices to Mariners", already mentioned, by which the captain of every vessel, owner, or citizen is entitled to receive without cost. Notice of all temporary or permanent obstructions to navigation, of whatever nature, and from these notices the captain may, without cost to himself, keep his charts corrected up to date, at a very small expenditure of time and trouble. The importance of this work may be realized when we reflect that a simple grounding is liable to cost a vessel owner anywhere from ten to one hundred thousand dollars, while the wreck may mean the destruction of three millions of property and the deaths of hundreds of people, as has occurred in the wrecks of transatlantic steamers in the Strait of Belle Isle.

Coming back to our chart you will notice that it is divided by meridians of longitude and parallels of latitude and on the edges of the chart these are subdivided into degrees and minutes, so that

with the aid of parallel rulers and dividers the position of any shoal may be accurately determined in degrees of latitude and longitude.

You will also notice in various portions of the chart circles concentric with each other, divided into points and quarter-points of the compass, as well as degrees, this is what is termed a "compass rose," and the inner one is placed there to show the direction taken by a compass needle in that locality.

The general public implicitly believes that the needle of a compass always points north. This has been exemplified in the proverb, "As true as the needle to the pole," As a matter of fact, the needle does not point to the pole, except in a few positions on the earth's surface, and even these positions are constantly changing. This reminds me of a story.

A school teacher in Kansas wrote a poem in which she called the lobster "the Cardinal of the Sea."

As a poetic figure it was new and attracted instant attention and our Kansas poetess was in a fair way to attain permanent fame until a Connecticut pointed out that a lobster was never red until it was boiled. It would have saved millions of dollars to the shipping world had the "true as the needle to the pole" simile been corrected by someone years ago. One of the first things the navigator has to learn is the tendancy of the compass needle to point in any direction except true north.

It has been the work of the Hydrographic Office, assisted by the navies of the other nations, to determine and prepare a chart showing the numerous vagaries assumed by the compass needle. This is known as the magnetic chart, these curved lines showing the magnetic direction of the needle at various points on the earth's surface the North Pole being located in about 70° N. Latitude, 97 ° W. Longitude. Instead of being a point like the geographical pole it covers an area about fifty square miles, as was determined by a corps of English naval officers in 1833. The south magnetic pole is in about 76° S. Latitude, 168° E. Longitude, and has never been visited, owing to the impenetrable barriers of ice. You will notice on the chart the magnetic equator, which is a sinuous curve crossing the geographical equator at two points, namely about 16° W. Longitude and 168° W. Longitude, the greatest divergence you will notice is in Brazil where the line is at 16° S. Latitude. One of the lines of no variation (on which the needle points to the true as well as to the magnetic north)

passes very near our vicinity, through the east end of Lake Superior, west of the Straits of Mackinac and down through Michigan. The navigator will find the magnetic variation of the locality he is in always printed on his chart, and if there is much difference, there will be several of these roses, each giving the proper allowance for that locality.

Probably the greatest menace to navigation and one which the average navigator fears as they are so low in the water that they cannot be seen by the lookout at night you will note on the chart before you symbols of these derelicts. We frequently read of vessels which have put to sea and never been heard of afterwards, and we can easily imagine that some of them have been lost through collision with these floating dangers. These derelicts are reported to the Hydrographic Office and are plotted on the chart as an approximate guidance to navigators. Whenever it can be done the Navy Department orders men-of-war to destroy these wrecks, by blowing them up so that they will sink. Many, however, float for months and years before they find their last resting place. A case or two of such may be interesting.

A three masted schooner, "The Fannie E. Wolston," was abandoned on October 15, 1891, and frequently seen after that for 1,101 days, three years and six days, at the end of which time, after traveling about 9,000 miles, she was lost sight of.

Another case was that of the lumber laden schooner "W. L. White." She was abandoned waterlogged about eighty miles off the capes of the Delaware during the great blizzard of March, 1888. She drifted 5,910 miles, following the Gulf Stream a good ways across the Atlantic ocean, and after a varied course was sighted about eleven months later stranded on one of the Hebrides, having been sighted and reported in her driftings by the officers of forty-five different vessels that chanced across her in various localities. For a period of over six months of this time she was a serious menace to the transatlantic commerce.

In conclusion I desire to extend to each and every one a cordial invitation to visit the Hydrographic Office, Room 528, Federal Bldg., where we will be pleased to explain to you any and all the nature of our work.

SOME DIRECTIONS FOR ELEMENTARY LABORATORY WORK IN PHYSIOLOGY AND HYGIENE.

By Louis Murbach.

[CONTINUED FROM THE DECEMBER, 1905, NUMBER.]

A portion of the sweet milk is sterilized by boiling (see experiment 1g, Bacteria) in a test tube plugged with cotton to see what the result is. How can milk be kept sweet longer than otherwise without ice? What other advantage even if used at once?

Note.—Experiment 5 under digestion may be done here with sweet milk.

To learn whether there is any formalin in milk: Some of the fresh milk is placed in a test tube, a little Phloroglucin powder (as much as can be held on a pen-knife point) is added, and then some alkali and the whole warmed gradually. If formalin is present a reddish or pink shade will appear in the milk. If none appears the student may add a drop of Formalin to see the characteristic color. Results? What have you learned?

Milk is tested to see what nutrients are present: It is better to test for starch and suar first, waiting for the proteid and fat until the next lesson as the proteid wil then be coagulated and the cream collected on the surface.

Note.—Although the sugar in milk (milk sugar, sacra lac) gives the test color for glucose it is not the same; it is an exception referred to in the sugar test, q. v.

A quantity of milk may be evaporated to get the solids. These are then burned in a porcelain crucible to see whether there is any mineral ash (that will not burn up). What is the result; what the conclusion?

DIGESTION.

Introductory Note.—We learn that the nutrients in food must be dissolved in order to be absorbed through the walls of the intestine. It will be of interest to see which ones are easily soluble in water in the form they are ordinarily taken as foods. While doing this work the student must also be sure that he understands what is meant when we speak of anything being soluble or of solution As indicated above, solubility in water is meant.

SOLUTION.

Experiment 1. Ordinary starch is shaken with water and filtered through several thicknesses of filter paper first wet with

water. The liquid passing through the filter paper (the filtrate) is then tested to see if starch easily passes through the filter paper or has been dissolved in water. The test in this and the following cases is a practical application of what the student has already learned. (See Foods and Nutrients 1a.) What is the result? Conclusion?

NOTE.—All results should be shown to the instructor, so as to avoid errors.

EXPERIMENT 2. Some grape sugar is shaken with water and filtered through several thicknesses of filter paper. After testing the filtrate to find if any sugar has dissolved write the result; then your conclusion, adding whether you think sugar can be absorbed without further digestion.

EXPERIMENT 3. Olive oil (or any other fat) is shaken in water and filtered with the same precautions as were observed in the other cases. Here again the filtrate is tested to see if any of the oil has dissolved in the water. How can you tell? Keep the result of this test until you are sure about the conclusion.

EXPERIMENT 4. As most of the proteid we eat is first subjected to heat, some boiled proteid is shaken in water and the mixture filtered through wet filter paper. As before, test the filtrate, report your result and record your conclusion.

NOTE.—Some kinds of raw proteids, trac. s of oil and starch to some extent, will pass through wet filter paper, and we should remember that in the intestine where the food is absorbed there is a moist living membrane, not wet filter paper such as we used in the above experimnts. It will be interesting now to learn what the action of each of the digestive juices is on some of the nutrients as shown in the following experiments.

DIGESTION PROPER.

EXPERIMENT 1. In a test tube are placed a few fragments of starch, some water is added, and the whole shaken to mix thoroughly; boiled until the mixture becomes clear. The starch paste thus made is divided in two test tubes; a, b; saliva is added to one, a) by allowing it to flow directly from the lips into the tube. Some more saliva is placed in a third tube, c). Now a little of the starch paste in b) is taken in the mouth and thoroughly mixed with saliva until a difference in the starchy taste is noticed. What is the taste? To see if the same thing has taken place in the test-tube mixture of starch and saliva, test with caustic potash and copper sulphate. What is the result? Before drawing a conclusion test for sugar the starch in b) and the sa-

liva in c). Do you find sugar in either? What must be its source in a)? Give reasons for your answers including b) and c).

NOTE.—See introductory note on similarity between starch and sugar, under Foods and Nutrients.

Any student having the time may test the action of saliva on proteid and fat.

EXPERIMENT 1*. In this connection it will be interesting to learn how the parts of a very young seedling plant can get and use the starch stored in the seed. Wheat kernels that have been germinated until the stems are about 1 inch long are dried and crushed. Some of this is tested for sugar after boiling with water enough to cover the powder. What is the result? If you have any doubt about the result (better show it) test crushed wheat that has not been germinated. Now tell what you learn from the experiment.

EXPERIMENT 2. To find what effect acid gastric juice, found in the stomach, has on proteid: Some proteid is placed in enough acid gastric juice in a test tube to cover the proteid. This is kept at the temperature of the body (98.5° F.) at least four hours. The result will be seen at the next class period. At that time the result and conclusion are to be written, with a sentence on the practical application.

Students may observe the action of alkaline gastric juice on proteid, and on starch paste in the sample experiments on the supply table and write up. This experiment is interesting since normally gastric juice is not alkaline.

EXPERIMENT 3. To find whether gastric juice or pancreatic juice, which occurs in the small intestine, mixes more readily with fat: Mix a little olive oil in a test tube with an equal quantity of gastric juice and the same in another test tube with an equal amount of pancreatic juice. What is the result in appearance? What conclusion?

NOTE.—In the alimentary canal fat is only slightly dissolved (a little soap is formed), but can be absorbed as an emulsion, a kind of milky mixture.

EXPERIMENT 4. To learn whether starch and proteid are affected by pancreatic juice: In one test tube is placed some proteid, in another some starch paste, and pancreatic juice is added to each. The one with proteid is set aside under the same conditions as the one with proteid and gastric juice (Ex. 2). While waiting for this result test the mixture of starch paste and

pancreatic juice. Better results are obtained after one day. If you are not sure how to test compare experiment 1a. What is the result? How does the pancreatic juice make starch soluble? How do you tell?

Now summarize the effect of saliva and pancreatic juice on starch, of gastric and pancreatic juice on proteid and on fat. If it has not previously been done the fat emulsion and milk should be compared as to their appearance, under the microscope.

EXPERIMENT 5. To learn the action of rennin, another ferment in the stomach: About 5 cubic centimeters of fresh milk are placed in a test tube a little rennin powder (as much as may be held on a pen-knife point) added, mixed thoroughly, and warmed over the Bunsen flame. It is important not to heat the mixture too much. How does the milk change in consistency? What is the common name applied to such milk?

NOTE.—This is the way milk is treated in making cheese. All milk taken into the stomach is first coagulated and then digested.

What is the use of rennin in digestion? Does it digest the milk (food)? For this reason it was not studied in the experiment on gastric juice.

(*To be Continued.*)

THE TRUTH ABOUT OLEOMARGARINE

Oleomargarine is a product which has long been regarded with suspicion, but food experts pronounce it "healthful and nutritious," and confute the statements ignorantly made that it is impure and contains injurious ingredients. A defense of this much-maligned article of diet is well presented by Mary Hinman Abel in the *Delineator* for February, being the sixth of her papers on "Safe Foods and How to Get Them." Mrs. Abel quotes Professor Harrington in his work on *Practical Hygiene*, significantly:

"Oleomargarine has been misrepresented to the public to a greater extent probably than any other article of food. From the time of its first appearance in the market as a competitor of butter, there has been a constant attempt to create and foster a prejudice against it as an unwholesome article made from unclean refuse of various kinds, a vehicle for diseased germs, and a disseminator of tapeworms and other unwelcome parasites. It has been said to have been made from soap grease, from the carcasses of animals dead of disease and from a variety of other articles equally unadapted to its manufacture. The publication of a great mass of untruth cannot fail to have at least its desired effect, not solely on the minds of the ignorant but even on those of persons of more than average intelligence. So a prejudice was created against this valuable food product, but it is becoming gradually less pronounced."

HIGH SCHOOL BACTERIOLOGY.*

By Wilfred H. Manwaring, M. D.,

Associate Professor of Pathology and Bacteriology, Indiana University.

There exists today on the statue books of every state and territory a law requiring the teaching of the nature, cause and prevention of transmissible diseases in public schools. No law was ever based on more humane motives. No law should be of more wide felt benefit. Yet the fact exists that this law has not the support of the teaching profession.

Through ignorance and neglect on the part of teachers, through laxity and indifference on the part of boards of education and supervising officers, real teaching of the nature of infectious diseases in public schools is practically non-existent. It is to remedy this defect that the medical profession advocates the introduction, in public high and normal schools, of an elementary course in bacteriology.

The foundation of modern medicine, modern surgery, modern gynecology and obstetrics, as well as of modern hygiene, rests on a knowledge of the properties of certain minute micro-organisms: pathogenic yeasts, pathogenic bacteria and pathogenic protoza. Preventive medicine is but an intelligent application of this knowledge in the war against infection. Yet, the surprising fact exists, that of the thousands of teachers of elementary physiology and hygiene in the United States, teachers supported by the public purse and required by law to impart this knowledge, practically none are familiar with the simplest elements of bacteriology, practically none have ever received the first rudimentary training in this fundamental subject.

During six years' experience in the secondary schools of the Mississippi Valley. I fail to find a single high school teacher who had this training, and met but one normal school instructor who professed it. In no other secondary school subject is there such a total lack of preparation.

The reason for this is primarily the great inertia of the teaching profession. While bacteriology has grown to gigantic proportions as a medical science and has revolutionized every branch of medical practice, its effect upon the teaching profession has

*Address before the Indiana Academy of Sciences at Indianapolis, December 1, 1905.

been largely to excite scepticism and engender ridicule. How often is the medical man approached by teachers with the inquiry "Honestly now, Doctor, do you *really* believe in germs?" Teachers of the United States, wake up!

The idea is unfortunately prevalent that bacteriology is one of the very difficult, most exacting of the advanced studies of the university. The fact is that the essential technique of bacteriology can be mastered, in two weeks' time, by any wide-awake lad of twelve, and its truths redemonstrated by the most unskilled pupil of high school age.

A number of years ago, working with a small body of secondary students, I proved this to my own satisfaction. It is to show you, today, that the statement is true, that I have planned to repeat before you some simple experiments fitted for high school classes.

I have before me on this table, apparatus that can be purchased in the open market of your city, for less than $5.00. This is the complete equipment necessary for the demonstration of many important facts of bacteriology to a high school class. Is there a high school in the land, worthy of the name, that cannot afford it? And one has but to increase the number of test tubes and other small articles on a table, to make an equipment for individual laboratory work in this subject. Fifteen dollars purchases the necessary equipment for a class of twenty-five.

The high school pupil heats a number of these shallow glass dishes in a tin oven like the one before you, or one that he improvises out of pieces of stove pipe, and thus prepares sterile receptacles in which to grow bacteria. He boils a little of this dried extract of seaweed, adds a pinch of salt, a small amount of peptone and beef extract, makes the resulting mixture very slightly alkaline with baking soda, clarifies and filters it under the direction of the teacher, and, when cool, has this jelly-like substance, a culture medium for micro-organisms. He places a little of this medium in several test tubes, heats them in this simple steaming apparatus, to render it sterile, and is ready for his experiments.

And the first experiment he will probably do will be the isolation of bacteria from air. He will melt the medium in a couple of test tubes, by immersing the tubes, as I am now doing, in boiling water, and will then pour it into a couple of his sterilized glass dishes. The liquefied culture medium immediately solidifies, as

you see, to form a thin layer on the bottom of the dish. One of these dishes he places one side, and it remains unchanged indefinitely. The dish I now pass around was made in this way several weeks ago. It is sealed with paraffine, simply to prevent evaporation and facilitate handling.

The second dish he opens for a number of minutes, so that floating germs of air may settle on the surface of the culture medium in it. He then sets this dish aside, and, in a day or two, there appear on its surface a number of opaque, white or variously colored spots, colonies of bacteria. He has caught floating micro-organisms of the air, and each micro-organism so caught has multiplied to form a mass of daughter micro-organisms.

And now, if the equipment of your laboratory includes a compound microscope, he studies these germs microscopically. He touches a colony, as I am now doing, with a fine platinum wire, mixes the bacteria adhering to the wire in a tiny drop of water on a glass slide, covers it with a cover glass, and observes the micro-organisms; some round, some elongated; some straight, some curved; some motionless, some darting hither and thither. Or he may allow the water on the slide to evaporate, and may stain the bacteria, in this simple manner, and so bring out their finer structure.

His second experiment may be to demonstrate bacteria in a liquid. He will melt the medium in a test tube, as before, will then allow it to cool to about body temperature, so as not to be hot enough to kill micro-organism, and then with this small loop of platinum wire will transfer it to a tiny drop of water, milk, saliva, or other fluid to be examined. And now, before the medium solidifies, he pours it into a sterile dish.

Around each germ thus transferred to the medium, there develops a colony of bacteria, visible to the naked eye, which in turn furnishes a rich field for further microscopic study. On this dish, prepared with a loopful of tap water, twenty colonies have developed; on this prepared from milk, over a thousand have grown; and on the third from saliva, ten thousand or more.

The colonies obtained in any of the above ways, he may transfer to medium in a test tube, as I am now doing, and get in this way, isolated, pure cultures of these germs. A number of such cultures, most of them obtained from air and water, I now present for your observation.

Having completed this preliminary work, the high school stu-

dent may attempt the solution of some important problem. For instance, a small amount of the milk that gave in the above experiment a thousand colonies per loopful, may be gently heated for a few minutes, and then re-examined and found to give but three or four colonies per loopful, or it may be boiled for a time and then found to be absolutely free from bacteria. Or, a small amount of water, which gave in the above experiment twenty colonies per loopful, may be frozen, by immersing in a mixture of salt and ice, and, after remaining solid for a considerable time, melted, re-examined and found still to give twenty colonies per loopful.

Have such experiments no bearing on problems of infant feeding or of the ice supply of cities?

He can in this way test milk or other substances, after drying, after exposure to sunlight, after the addition of carbolic acid, and prove other facts equally far-reaching in their application to human life. He may add to the milk an artificial gastric juice, which he readily prepares from a little pepsin and hydrochloric acid, and show how the healthy human stomach kills untold millions of micro-organisms. He may add a few drops of his own blood to a drop of milk, as I am now doing, and show that human serum possesses wonderful bacteria-killing powers. Facts of inestimable value in the prevention of disease.

Finally, I would recommend that he take a mass of the bacteria he has grown in the test tube and inoculate it under the skin of a white mouse or guinea pig, two of the most delicate animals obtainable, and show that the common bacteria of air, water and milk are absolutely harmless. He may thus escape the terror of environment that modern pseudo-science engenders. He still remembers to fear, but fears intelligently.

This, ladies and gentlemen, is but a hint as to the nature of a high school course in bacteriology.* It is believed by leading medical scientists that the introduction of such a course in the high schools and normal schools of the country would be of far-reaching benefit to society. It would form a real scientific foundation, that would prepare the way for beneficial legislation and make possible honest, intelligent co-operation. It would thus fulfill the spirit, as well as the letter, of the law requiring the teaching of the nature of infectious diseases in public schools. In your hands I leave it.

*For a more detailed account of these experiments see this journal for March, 1905.

THE EQUIPMENT OF A MODERN CHEMICAL LABORATORY IN THE SECONDARY SCHOOL.

BY FRED J. WATSON,
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In no particular has the secondary school of to-day made a greater advance over that of a generation ago than in the methods and appliances of science teaching. The single "science room" of the old high school or academy, with the crude apparatus by whose aid one overworked teacher was supposed to give instruction in botany, zoology, geology, astronomy, physics, and chemistry, has given place, in the best equipped buildings, to separate laboratories for each science, fitted up in a manner far superior to those of any college in former days, and with teachers especially educated for the work, and confining their attention to one, or at most two sciences. In this process of development, chemistry, by reason perhaps of its connection with the professions of medicine, pharmacy, and metallurgy, was the first to be provided with a separate laboratory, and the first, also, in which the pupils, as well as the teacher, were allowed to handle the apparatus, and to perform experiments for themselves. And I doubt if there is any science in which these improved facilities have yielded larger dividends of improved work than in the case of chemistry.

It has been my fortune to teach chemistry in schools of nearly every stage of development between the two described above, and as the building in which I am now located is the most recently completed of the high schools of Chicago, I will devote my paper to a description of its present equipment, indicating, from time to time, how I think that equipment might be improved.

The department of chemistry occupies five rooms on the third floor, the lecture-room, teacher's room, store-room, main laboratory, and balance-room. The lecture-room, thirty feet square, has chairs, with tablet arms, for forty-eight pupils. It is well lighted from the north and east. A case for apparatus and one for chemicals are in opposite corners, the remainder of the wall space is occupied by blackboards. The lecture table is twelve feet long, three feet wide, and three feet high, and has a soapstone top. Across one end is a bottle rack, at the other a sink provided with a hanging shelf for gas receivers, and a steam

pipe for supplying hot water. Gas and water pipes are carried the entire length of the table, in a trough under the edge. A switch-board at one end provides electrical currents, both alternating and direct. A fume-case, and a Bunsen pump with compressed air attachment, complete the stationary outfit of the room. A much needed improvement would be a series of raised platforms under the chairs, as it is difficult for those in the rear to get a good view of the table.

Our stock of lecture apparatus is large and varied, having been purchased at different times and by different instructors, and includes many pieces for which I can see but little use in a high school course, where experiments must be very simple if we are to avoid the danger of so loading the mind of the pupil with details that he will miss the point of the experiment. Among the more useful articles I may mention a water voltameter, an apparatus for the electrolysis of hydrogen chlorid, a number of eudiometers, one arranged for showing the volume of water vapor produced, a Berzelius gas-holder of five gallons capacity, two large pneumatic troughs of glass, two Liebig's condensers of glass, a Dobereiner's lamp, a Davy's safety lamp, an oxy-hydrogen blowpipe, with cylinders for holding the gases, a combustion furnace, an apparatus for illustrating the manufacture of sulphuric acid, two gas-pipe retorts, one for the manufacture of oxygen, the other for that of illuminating gas, and a supply of footed test tubes, Woulff bottles, beakers of various sizes, porcelain combustion tubes, tubes and cylinders for calcium chloride, potash bulbs, separatory funnels, etc. The room is arranged for work with the stereopticon, and an instrument can be obtained at any time from the physical laboratory. We have as yet no outfit of slides, but a dark room and a camera furnish all the facilities, except time and skill, necessary for preparing them. We have, however, a considerable number of charts, prepared by the pupils of the drawing class, and illustrating the principal processes of industrial chemistry. These have certain advantages over slides, as they are larger, can be left hanging upon the walls and referred to at any time, and can be displayed with far less trouble.

A passage connects the lecture-room with the main laboratory. On one side of this passage are the instructor's laboratory, which also communicates with both rooms and the stock room. Of the latter very little need be said. Its walls are lined with cup-

boards, including a tall narrow one for holding glass tubing, and contain the apparatus intended for occasional use, or to replace articles lost, broken, or otherwise used up during the year. The teacher's room contains a case of small drawers, several cupboards, a small desk, a broad shelf of slate next the windows, and a sink. The fume case in the lecture room opens into this apartment also, and distilled water is obtained from a tank in the attic, filled by a still in the engine room.

The students' laboratory is a room fifty feet by twenty-five feet, lighted on one side only, and containing five double tables, each half of which accommodates four pupils, or forty pupils in all. In the center of each double table is a hood, or fume-case, lined with lead, supplied with water and gas, equipped with spring doors, and ventilated by a down-draft. I have found it quite difficult to induce the pupils to use these hoods, as the doors are small and the spring hinges make it difficult to get apparatus into them. The draft, moreover, is available only when the fans are working, which is not always the case. I am inclined to think that a smaller number of large hoods, with up-draft, placed at the sides of the room, would be more satisfactory. We have one such at the end of the laboratory, and beside it is an electrical sand-bath, which would be much more available if placed at the side of the room.

The tables are thirty-six inches high, thus enabling the pupils either to sit or stand at their work. Their tops are of soapstone, which I consider, on the whole the most satisfactory material. It is less affected by heat and acids than are either wood or slate, and is not so hard on glassware as are slate and glass. Each half table, as I have said, accommodates four pupils, allowing each six square feet of space. In its center is a sink 24 inches by 12 inches, placed transversely to the length of the table, and provided with two faucets. At the bottom is a perforated plug which retains at all times an inch of water in the sink, thus keeping sediment out of the drain pipes. Shelves for holding receivers are placed at the ends. On each side of the sink is a double bottle rack of iron, with glass shelves, each half large enough to hold twenty-four 4 oz. bottles. Under each half is a gas cock and a water faucet. The latter is absolutely useless, except when an inexperienced or mischievous student adds variety to his experiment by mistaking it for the gas cock. A much better place for the racks would be across the ends of the table. This would

make it easier for the students to use the sinks as pneumatic troughs, would increase the amount of available space at each desk, and would give the teacher an unobstructed view down the rows of tables. The lower shelf should be, but is not, of sufficient height to hold an 8 oz. bottle, of which each pupil has four, three for the common acids and one for ammonium hydroxid. Each table is also provided with a resistance box for electrolytic experiments.

As the room is designed to accommodate four sections, each quarter of the table is provided with four drawers and a narrow cupboard with two shelves. Each student has a separate drawer, four pupils may share a cupboard. Each drawer contains a package of filters, a piece of platinum wire and a small square of platinum foil, a book of litmus paper, a blow pipe, a pair of pincers, a test-tube holder, an iron spoon, a small evaporating dish, an ignition tube, and a half dozen test-tubes. Each cupboard holds two wire racks for test-tubes, two funnels, two beakers, a small mortar, a set of cork-cutters, a file, a sand-bath, and a graduated cylinder. These articles are delivered to the students at the beginning of the year, and receipts taken for them. Each student has a key for his drawer and another for his cupboard, while the teacher is supplied with a master key. A Bunsen burner is attached to each gas cock, and a washing flask is placed on each bottle rack. A recess between the cupboard and the drawers provides a place for a slop jar, and a large cupboard underneath the hood holds four ring stands, a tripod, two gas generators, and eight receivers of various sizes.

Along the side of the room next the windows runs a broad shelf of slate, serving as a side table. This, being well lighted, is a fine place for working with burettes, gas measuring tubes, and the like. It also holds a small anvil, a blast lamp, and various bottles of seldom used reagents, and is provided with gas cocks to which are attached Bunsen burners for heating water baths. The latter consist of six inch pans of pressed tin, with covers of the same material, in the center of which a hole an inch and a half in diameter is cut.

The south and west sides of the room are lined with cases, one of which contains the reference library, the others, the apparatus and reagents required for occasional use during the year. About one-fifth of the space is occupied by drawers, the rest by shelves, Two cases of small drawers are a great convenience, as they

facilitate the classification of corks, tubes, etc., according to size, Dry reagents are kept in wide mouthed bottles, or in tin cans; liquids in half gallon bottles. To economize time in the distribution of materials, and at the same time obviate, as far as possible, the necessity of the students leaving their places, I have adopted the following plan. For each reagent twenty bottles are provided; four ounce bottles with glass stoppers for the liquids, six ounce packing bottles, with wide mouths, for the solids. A light tray of wood is made for each set of twenty bottles, and these trays are arranged, in alphabetical order, upon the shelves. Two pupils can, in a very few minutes, distribute to the various racks the materials required for the day's experiments, collecting on the same trays, as they go along, the bottles used on the preceding day.

The hydrogen sulphid problem I have not yet succeeded in solving. The Kipp and Mitscherlisch apparatus are both too liable, in the hands of pupils, to get out of order; an arrangement described in an early number of SCHOOL SCIENCE, and consisting of two bottles connected by a bent tube, is good, but too large for the limited space in our fume-cases. Except where complete precipitation is required, a saturated solution of the reagent, contained in quart bottles of orange colored glass upon the side table, is fairly satisfactory.

Our balances are in very bad condition, from lack of a separate room for them in our former quarters. Our present balance room accommodates ten of them in separate cases, with room for four more on an open shelf. Three tripple beam balances, newly purchased, give the best satisfaction of any. They are accurate to a centigram, and possess the great advantage that the weights cannot be lost.

A small direct vision spectroscope, a barometer, two dozen thermometers, and a supply of porcelain crucibles, aspirator bottles, burettes, and gas measuring tubes, are among the articles occasionally used by the students, and served out to them as occasion demands. A type writer and a neostyle enable the instructor, when he has time for the work, to prepare supplementary lectures and experiments for his classes. As, however, no laboratory assistant is provided, and the instructor in chemistry is expected to take charge of a room and hear recitations in at least one other subject, it will readily be seen that his time for work of this description is somewhat limited.

PRESENT TENDENCIES IN THE TEACHING OF ELEMENTARY PHYSICS.

BY R. A. MILLIKAN,
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[CONTINUED FROM THE FEBRUARY NUMBER.]

III. A third tendency which I note is *a tendency away from the slavish use of the text book.* The text book is becoming more and more, and it ought to become more than it is now, a *reference* and *review* book, not the source of the student's first impression of the subject. I am convinced that the assignment of advance lessons on which the student is expected to recite before the subject has been developed by the teacher, is thoroughly bad, and I am glad to note that it is passing away. The student's introduction to every subject should come either through the laboratory, or through class room demonstrations, accompanied by informal discussions. After his interest has been aroused in either, or both, of these ways, after he has definite, concrete experiments to bring before his mind's eye as he attempts to read and to reason, he is ready for a text book assignment, followed by a quiz and the solution of problems. The text book is absolutely necessary in my opinion to the successful and economical conduct of a course; but it must be put in its proper place. No greater mistake can be made than to confound the function of the text book with that of the teacher, as is sometimes done. I take it that the function of the text book is not to raise questions either for the sake of answering them, or for the sake of leaving them unanswered, in order to make the puipil think for himself. In a word, the text book should not be a prolonged interrogation point. But this is exactly what the teacher *ought* to be. He should draw out the student by question and answer of every conceivable kind. I believe thoroughly in the Socratic method of teaching, but I think it is the teacher's place to use it, not the texts. The aim of the latter should be simply to bring the student accurate information in regard to the facts and theories of physics, stated in the simplest possible way, and the chief use should be to clinch and supplement the teaching of the class room.

IV. A fourth tendency is *toward a closer correlation between*

laboratory and class room work, the laboratory exercises for the most part *preceding* the class room discussion, and furnishing the concrete images which the student needs to group his thought processes about. I am aware that there are good teachers who invert this order and insist that the student shall know just what he is going to do before he enters the laboratory, and I admit that I myself find some subjects to which I prefer to introduce the student through the medium of the class room demonstration. Nevertheless, I am convinced that in the main the student's own handling of apparatus in the laboratory is his best introduction to most of the branches of physics, particularly if the laboratory is equipped for keeping all of the students working on the same experiment at the same time, for with this arrangement such explanations as the teacher finds desirable can be made to the class at any time during a laboratory period, At any rate, whichever arrangement may be the better, I am certain that the practice of having the laboratory work precede is growing rapidly at the present time.

Every course in physics ought to be arranged so that the students have in the laboratory two double periods per week, and in the class room three single periods. The class room period should be devoted, I think, partly to new and carefully selected class room experiments, partly to informal discussion of these experiments, and partly to quiz work upon review assignments and problems. The problem work should not be bunched at the end of chapters, but should be, as far as possible, a part of each day's assignment.

As to the laboratory work, I regret to say that despite the agitation of the last twenty years, it is not yet receiving in many schools, the attention, either in the way of equipment or of time, which it imperatively demands. The expense necessary for the conduct of a thoroughly good laboratory course is not large. From $60 to $75 will buy a complete set of just as good apparatus as is desirable for a beginning course, and five such sets will enable one to conduct satisfactorily a laboratory division of twenty pupils, although half as many sets as there are pupils is to be preferred.

V. With reference to *the role of mathematics in physics,* I have no hesitation in saying that in the past we have unquestionably attempted to force too many abstract pieces of mathematical analysis upon the brains of adolescents, and I am glad

to note that there is a tendency at present toward its elimination. We need to bear continually in mind that the function of a course in physics is not to assist in teaching mathematics or even to constitute a review of algebra and geometry. *It is rather to open the student's eyes to the meaning of the great world of physical phenomena with which he is surrounded.* Such little algebra and geometry as is necessary to this end should be freely used, but too much of it is likely to direct attention away from the real aim and value of the course. The chief mathematical demand which elementary physics makes upon the student is that he shall be able to state in algebraic form simple relations, the verbal statement of which he knows, and conversely that he shall be able to state verbally physical relations which are put to him in the form of an equation. In a word, he must be able to *think in symbols*—to translate words into symbols, and symbols to words, and also in some instances, at least, to translate words and symbols into graphs. But all the subtler bits of mathematical analysis in which physical relations are lost sight of while equations are being manipulated, are suitable only for a course designed for pupils in whom maturity has brought the power of abstract reasoning. These analyses should be diligently weeded out of elementary courses. They have found a place in them only because our elementary texts have been in so many cases only condensed reproductions of college texts—abridged Ganots, but less intelligible to the high school pupil even than Ganot, because all of the meat has been taken off Ganot's bones. There is certainly agreement among most of the thoughtful students of the problem of elementary physics instruction in regard to the unwisdom of introducing these mathematical processes. President Hall's chief criticism of present methods of teaching science is directed toward this defect. But here again it seems much easier to see a difficulty than it is to remedy it. Some of those who are calling most loudly for reform are guilty of perpetrating upon high school pupils the worst possible mathematical monstrosities.

I do not wish to be understood to be here criticising the movement toward the closer correlation of mathematics and science. I am in thorough sympathy with the attempt to make high school mathematics, as well as high school physics, less philosophic and more practical and concrete than it now is through the injection of practical problems into it: and, from the standpoint of

the work in mathematics, some pieces of physical analysis which should not be put into the one year course in physics may become possible in a correlated course for the simple reason that time is gained for them which is now given to some of the more abstract and involved phases of mathematics. I am speaking now, however, solely from the standpoint of the present one year course in physics—a course which is likely to retain much of its present character even though some of the mathematical phases of physics are taught in connection with the mathematics work.

Since this discussion will be of little value to physics teachers unless it is concrete I will attempt to review a number of mathematical considerations which it is desirable in my opinion to eliminate from the elementary physics course, either because they are better adapted to a later stage of mental development, or because they consume time to the exclusion of some of the more practical and vastly more important phases of physics, time which might be spent in laboratory work now crowded out, in the practical study of electrical and optical instruments which the student sees about him on every side and wants to know more about, in trips to factories, museums etc.

(1). Our worst mathematical sins I think are found in our problems. I am a thorough believer in problems, but I believe that they should be given solely for the sake of driving home physical principles, not for the sake of developing skill in the legerdemain of mathematics. Mathematical puzzles may have some place in an algebra, but certainly not in a physics text.

(2). The development of the formula for falling bodies which are projected downward, or horizontally, with initial velocities is I think of little value and consumes much time. In general the discussion of uniformly accelerated motion and Newton's Second Law are given a wholly unwise prominence in many beginning courses.

(3). The mathematical treatment of the laws of impact, with its turning over of the equation $m\,v + m'\,v' = m\,u + m'u'$ is in my judgment wholly out of place in the first year course. Nothing more than a hasty and somewhat superficial treatment of the Third Law can be comprehended by high school pupils anyway, and we make one of our worst blunders in trying to treat it fully.

(4). The mathematical treatment of the laws of curvilinear motion $f = \frac{m\,v}{R}$ is, I think, one of the worst violations of ado-

lescent nature which can be possibly committed. In fact I know of but one more glaring fault of this kind, and that is,

(5). The mathematical development of the laws of simple harmonic motion, $t = \pi\sqrt{\frac{m}{F}}$ and $t = \pi\sqrt{\frac{l}{g}}$. This seems to me to be qu'te preposterous.

(6). The development for the general case from the formula $E = f s$, $f = m a$, and $v = a t$ of the equation for kinetic energy seems to me to be quite unwise. In my own elementary work I do indeed develop and use this formula, but I derive it from a simple concrete case. I find how much work a moving body can do in raising itself against gravity. Knowing that it will rise to a height which is given by $v = \sqrt{2 gs}$ we find at once that its kinetic energy is equal to $\frac{1}{2} mv^2$.

(7). The development of the general equation of gases, $P V = R T$, is on the whole undesirable. The time can be spent much more profitably in driving home and applying the law of change of volume with pressure when the temperature remains constant and the law of change of volume with absolute temperature when the pressure remains constant. It is better drill for the student to work out for himself from these two laws the final volume when both pressure and temperature have changed than it is to learn to substitute mechanically in the equation $P V = R T$. And it is further a problem which he is able to work out for himself in a concrete case however bewildered he may become if you try to put the general case to him in symbolic form.

(8). The time spent in a proof of the relation between the cubical and linear coefficients of expansion of a solid is, I think, ill spent. I prefer to make no mention whatever of the cubical coefficient of a solid.

(9). The development of the formula for the height of rise of liquids in capillary tubes is a sheer waste of time in a beginning course and it is further misleading, because it gives a false notion of the nature of so-called surface tension.

(10). The development of the tangent galvanometer formula in a high school course is misdirected energy.

(11). The usual development of the mirror and lens formula $\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$ is not comprehended. The difficulty here is that

we get at it from the standpoint of rays rather than that of wave fronts, a standpoint which makes its development exceedingly simple.

(12). The presentation of the index of refraction as the ratio of the sines of the angles of incidence and refraction rather than the ratio of the velocities of light in the two media is to my mind unfortunate. Even if trigonometric functions were understood by high school pupils, which they are not, no high school student ever could understand why the index is the ratio of the sines. In my opinion trigonometric functions should be left severely alone in beginning physics.

(13). The last point which deserves mention under this head is the question of the advisability of requiring students to learn and use formulas the origin of which they cannot comprehend. It is a practice which, in general, tends to develop *memorizing* rather than *reasoning* habits, and to inject into physics courses a deadly, mechanical quality which physics above all other subjects ought not to possess. The two formulas which come most strongly under this condemnation are $t = \pi\sqrt{\frac{l}{g}}$ and $v = \sqrt{\frac{l}{g}}$ The last formula it is my own habit never to mention in elementary work. The first I do touch upon lightly in connection with laboratory work upon the pendulum.

I am well aware that most of the pit-falls above mentioned are already shunned by the majority of the most progressive teachers of elementary physics. Furthermore I do not wish to be understood to assert either that these particular thirteen are our only mathematical stumbling blocks, or, on the other hand, that all of these thirteen are under all circumstances bad. In general, however, they represent the direction in which many courses in physics are now being improved by the process of elimination.

VI. A last tendency to which I wish to direct attention is one *to do away with some of the time honored but misleading fictions of physics.* I refer especially to the fictitious explanations based upon rays of light. Although the usual treatment of surface tension, as well as that of the mechanism of tone production by wind instruments is in the same class. The treatment of image formation from the standpoint of wave fronts represents a movement which has indeed not gained such headway in this country

as it has in England, where the very foremost of English speaking physicists have been for ten years urging the basing of explanations in optics upon the "causally conditioning" facts of change of wave curvature instead of upon the fiction of rays. As a matter of fact the wave front view point furnishes not only a truer, but a simpler, clearer, and more practicable standpoint for the treatment of geometrical optics, even in the most elementary courses.

In conclusion permit me to repeat a remark which I remember making upon the occasion when I was first asked to teach a course in elementary physics, which was as a matter of fact the first subject which I ever taught. I replied to the principal from whom the request came about as follows: "I am very glad that it is physics which you wish me to teach, for a man who cannot interest pupils in that subject surely cannot interest them in anything. It is a subject which in itself, irrespective of the teacher, is the most fascinating in the whole category, and the man who cannot succeed at it was surely not meant for a teacher." I am still of the same opinion.

AN INTERESTING EXPERIMENT WITH PHOSPHORUS.

By Nicholas Knight,
Cornell College, Mount Vernon, Iowa.

If a stick of phosphorus five or six cms long is placed in a moderately concentrated solution of copper sulphate, a coating of metallic copper will gradually collect on the phosphorus, sometimes crystals of copper will be observed, especially on the ends of the piece. A week may be required for the completion of the experiment, and the addition of more copper sulphate may be necessary. The equation which expresses the reaction is as follows:

$$2P+5\,Cu\,SO_4+8H_2O=5\,Cu+2H_3PO_4+5H_2SO_4.$$

An examination of the section on phosphorus in all the textbooks at hand failed to disclose any mention of the experiment. It is nevertheless a striking one, and can easily be given in any elementary course.

ON SCIENCE TEACHING. (V).

By C. R. Mann,

Ryerson Laboratory, University of Chicago.

In this article we shall mention some of the questions that bear on the problem of choice of subject matter for the course. As in the last article the point of view is that of a physics teacher, though most of the suggestions must apply equally well to other branches of science.

It is of course manifest that the selection of subject matter is dependent on the choice of a conscious teaching purpose,—in fact that the two are so closely interrelated that the solution of the one problem generally means the more or less complete solution of the other. Hence the following remarks may in a way be considered as a continuation of those of the last article.

In the first place we must not forget that the students come to us supplied with a great amount of qualitative information obtained from their general experience. In this scientific age, the daily life of every one is so closely in touch with the practical results of scientific work, that it is impossible for anyone not to have formed numerous more or less distinct concepts of the "go" of things in the world about him. To ignore this vital knowledge is surely a mistake: and to found the discussion of the principles of science on strange and unnatural laboratory experiments must seem to the student both unnecessary and uninteresting. Therefore the teacher must endeavor to use as much of these materials at hand as is possible; not as illustrations of "laws" derived from abstractions, but as means of building up the concepts expressed and related by the laws, and as the material that serves as the basis of the abstraction.

The decision as to which of the youthful experiences to use will depend on a number of factors. Primarily, however, on the teacher's teaching aim. For if that aim is to make up-to-date scientific encyclopedias of the students, the experiences selected will be as numerous and will bear on as many different topics as possible. But if that aim is to develop thinking power and incidentally to ram home some of the most general and fundamental principles of science, the experiences chosen, though varied, will be as simple and as closely related as can be found. And this problem is a large one, because at present the mass of scientific

material is so great that we are all guilty of cramming the beginner's memory pouches so full that he cannot swallow. How shall we settle it?

May we not be guided in making our decision as we would be in the corresponding case of the physical boy? Shall we not try to find out what the student needs for healthy, mental growth, what he can assimilate, and what nourishes him? Should not the course be framed from the point of view of the student's best development rather than from that of the physicist? By this is not meant that he should be fed only on the things which he likes—he might then try to live on candy and oranges. Rather, he should be given the most nourishing and above all the simplest diet, not be overfed, and have time to assimilate one meal before he is given the next. This is a question that cannot be settled by guess-work. It involves at least as careful an analysis of the essentials of boy mentality and its growth as has been given to the related physical problem.

The teacher has probably often been told this in the form of requirements in the study of psychology. But from the point of view of science teaching it means more than a mere study of this valuable subject. For psychology is a very young science, and the wide differences of opinion among its masters on vital points show that it has not yet attained those general and fundamental principles from which deductions may be made. And especially if the teacher's aim is to foster the scientific habit of thought, is psychology unable as yet to give very definite answers to his queries, since the modern logic has fortunately as yet defied our efforts toward formulation and systematization. It therefore follows that in this field the teacher must be something of an investigator and experimenter for himself. He must try different subject matter and different methods of presenting that matter on different classes and attempt to discover which serves best in carrying out his own conscious teaching aim.

This must not be taken to mean that the study of the various manuals of psychology and that of other similar works is to be neglected. Far from it. The science student is particularly culpable if he ignores such study. For he knows that one of the first steps in any really valuable investigation is the acquirement of a knowledge of what has already been accomplished in the solution of the problem. Hence he should assiduously study such works; he should read and ponder carefully the classics of peda-

gogy from Plato down; and he should also consider the educational development which they portray and which is depicted in some of the good histories of education, like those of Painter, Davidson, Laurie, etc. Above all he must apply the scientific method to this problem—must question conclusions, compare them, sift out those that appear less valid, and try to make new combinations, to suggest new ideas, and to draw new conclusions.

In opposition to what has just been said it may be urged that little is to be gained by the man who wishes to teach modern science from a study of the works of those who wrote before science appeared to play an important role in education. The use of natural science as an active educative factor in the schools appears to date back only fifty or a hundred years. But it must be clear on careful thought that no subject,—and especially not science, modern though it appear to be,—can sever its connection with the rest of the mental man without greatest injury primarily to itself.

Yet it would almost seem that the fact that science does not at present occupy in the educational system the important place which it is capable of taking is due to an implicit belief in some sort of exclusiveness on its part. If we science teachers understood better the relations that exist between our subject and the others, would we not be better able to make our science teaching play as important a part in education as science has played and is even now playing in civilization? May we not derive many hints as to the part science should play in the development of the individual, by a study of its activities in the growth of the whole of society?

But to return to the immediate problem, what further hints can we find that will assist us in choosing the subject matter of the course? Several will be found in Hanus's book on *Educational Aims and Educational Values.* The main one is, perhaps, "to connect the school interests with the life interests; in other words to so construct the school programs that stress is laid throughout on the boy's vocational and social interests." This point is probably so well understood nowadays that a passing mention of it will suffice.

Other important suggestions will be found in *Adolescence,* by G. Stanley Hall, especially in Vol. II, chapters X, XII, XV, XVI. We are particularly urged in this valuable work to dwell on practical applications of science first—on the things that go—

on toys of various sorts. All of these can be used as starting points from which to develop an understanding of principles even better than the finest apparatus, which usually presents the bare principle indecently stripped of its use and its vitality. On page 168 of the volume is sketched very briefly an outline of a course in elementary astronomy—a subject now almost extinct in the secondary schools. This may be taken as a sample of what may be accomplished in other lines. Every science teacher should read and ponder well at least these four chapters of this monumental work.

We may perhaps sum up what has been said as follows The teacher must know his pupils and their dominant interests; he must try to find out what stimulates and nourishes them; and he must use practical things with "go" in them just as much as he possibly can.

The practical difficulties presented in carrying out such a plan are very great. For we have fallen heir to a set of arid, parched, and lifeless experiments, and to a stock of laboratory apparatus for performing the same, which few school boards would consent to have scrapped. The whole thing resembles more a mummy than a living man, and its only just place is in a museum. Yet is it not far better that we stock a few museums with this sort of thing, and then, with the help of the more enthusiastic pupils, make a few toy machines and engines, than that we go on killing off the budding scientists and stifling the enthusiastic love of Nature and her works, a love that is inherent in every normal child?

A NEW MOVE AMONG PHYSICS TEACHERS.

A movement has recently been started among the teachers of physics for the purpose of attempting to make the elementary courses in physics more interesting and inspiring to the students. The first step in this advance is the sending out of the circular letter which is printed below. Anyone who is interested in this problem is invited to answer the letter and thereby get into touch with those of his colleagues who are striving for its solution.

At the last meeting of the Central Association of Science and Mathematics Teachers held in Chicago Dec. 1-2, 1905, the Physics Section appointed a committee of three to consider the advisability of approving the list of experiments for first year work in physics as adopted by the National Educational Association at its last meeting in July. This committee was also instructed to take such other steps as might seem desirable for strengthening the work in elementary physics. As a first step in this direction, the committee wishes to find out to what extent teachers are agreed on the list of experiments which should be used in the laboratory. We wish to know if it is possible to find a list of about seventy experiments on which a large number of teachers can agree, and which could then be used as a basis for closer contact between the high schools and the colleges, and as a means of infusing more interesting and vital experiments into the elementary courses.

The committee is sending this circular to as many physics teachers as they are able to find. We hope that every teacher will be ready to spend the time necessary to answer it and thus lend his aid to making the results as representative of the sentiment throughout the entire country as is possible. You are also invited to send in any questions which you would like to have submitted to teachers in this way. When the answers are in, the results will be compiled and a second circular giving the results of the first sent to all who answer this. This second circular may also contain further questions which may be suggested in the answers.

During the past three years, several lists similar to the proposed one have been adopted. In order to have a basis from which to start, the committee has combined two of these, namely, that of the North Central Association of Colleges and Secondary

Schools, and that of the National Educational Association; and the following list contains all the experiments which appear in either of these, together with several additional ones that have been recently used with good effect.

1. Weight of unit volume of a substance.
2. Lifting effect of water on a body entirely immersed in it.
3. Specific gravity of a solid body that will sink in water.
4. Specific gravity of a block of wood by use of a sinker.
5. Weight of water displaced by a floating body.
6. Specific gravity by the floating method.
7. Specific gravity of a liquid: two methods.
8. The straight lever, first class.
9. Center of gravity and weight of a lever.
10. Levers of the second and third class.
11. Force exerted at the fulcrum of a lever.
12. Errors of a spring balance: study of the Jolly balance.
13. Three forces in one plane applied at a point.
14. Inclined plane, force parallel to incline.
15. General laws of equilibrium in a plane. Four or more forces acting at different points, no two parallel.
16. Study of the statics of a crane or truss.
17. Efficiency of a set of pulleys.
18. Friction between solid bodies.
19. Coefficient of friction.
20. Breaking strength of a wire.
21. Comparison of wires in breaking tests.
22. Elasticity, stretching.
23. Elasticity, bending, effect of varying load.
24. Elasticity, bending, effect of varying dimensions.
25. Elasticity, twisting.
26. Study of the pendulum, law of lengths.
27. Horizontal pendulum, variation of period and force.
28. Compressibility of air, Boyle's law.
29. Density of air.
30. The barometer.
31. Open and closed manometers.
32. Comparison of masses by the acceleration test.
33. Action and reaction, elastic impact.
34. Inelastic impact.
35. Surface tension, both qualitative and quantitative.
36. Testing a mercury thermometer.
37. Linear expansion of a solid.
38. Increase of pressure of a gas heated at constant volume.
39. Increase of volume of a gas heated at constant pressure.
40. Work done by expanding gas, efficiency of hot air engine.
41. Specific heat.
42. Latent heat of melting ice.
43. Latent heat of vaporization.

44. Relation between pressure and temperature of saturated vapor.
45. Relative humidity and determination of the dew point.
46. Heat of combustion of illuminating gas.
47. Efficiency of a small gas engine.
48. Efficiency of a small water motor.
49. Efficiency of a small steam engine.
50. Newton's laws of cooling.
51. Change of boiling point with pressure.
52. Boiling point of alcohol by vapor pressure method.
53. Melting points of some substances like paraffine, wax, etc.
54. Waves on the surface of water, wave trough.
55. Waves on stretched strings.
56. Velocity of sound in open air.
57. Wave length of sound by resonance.
58. Number of vibrations of a tuning fork.
59. Longitudinal vibrations of springs, variations of period with load.
60. Electrostatic series.
61. Fundamental phenomena of electrostatics.
62. Fundamental phenomena of magnetism.
63. Map magnetic fields with iron filings.
64. Exploration of magnetic field with Jolly balance.
65. Lines of magnetic force about a galvanoscope.
66. Single fluid galvanic cell.
67. Two-fluid galvanic cell.
68. Battery grouping.
69. Action of magnet on current, D'Arsonval galvanometer.
70. Study of induced currents.
71. Resistance of wire by substitution, different lengths, cross-section, and multiple arc.
72. Resistance with the Wheatstone bridge.
73. Change of resistance with the temperature.
74. Heating effect of the current.
75. Battery resistance.
76. Electromagnet, poles in relation to direction of current.
77. Electric bell.
78. Telegraph sounder, key, and relay.
79. The electric motor.
80. The dynamo.
81. Electro-chemical series.
82. Electrotyping and electroplating.
83. Charge and discharge of a simple storage cell.
84. Fundamental phenomena of optics.
85. Images in a plane mirror.
86. Images by concave and convex cylindrical mirrors.
87. Multiple images; plane mirrors parallel and at an angle.
88. Index of refraction of glass.
89. Index of refraction of water.
90. Critical angle of glass or water.
91. Focal length of a converging lens.

92. Relation of image-distance to object-distance.
93. Shape and size of a real image formed by a lens.
94. Virtual image formed by lens.
95. Magnification of simple microscope.
96. Magnifying power of a telescope.
97. Determination of the wave length of light.
98. Study of the telescope and microscope.
99. Fundamental phenomena of spectrum analysis.
100. Use of the photometer.
101. Efficiency of an electric lamp.

You are requested to send the following information, numbering your answers to correspond with the questions:

1. From the above list select those experiments which you regard as essential for the first year's work in physics, and write their numbers in a list. Do not send in more than 60. Read the rest of the questions before making the list.

2. Are there other experiments which have proved particularly satisfactory which should be added to the list? Give their names with briefest description.

3. Which of the experiments in the list you selected do you find most successful with the students? Write the numbers only.

4. Are there any experiments which you would like to give the students but which you have not succeeded in making sufficiently simple or sufficiently acurate?

5. Do you ever use toys in your experiments? If so, what ones?

6. Can you suggest a criterion for judging the usefulness of a laboratory experiment? Do you approve of any of the following?

a. A laboratory experiment justifies its existence if it does nothing but illustrate clearly and simply some principle of physics.

b. A laboratory experiment justifies its existence only when it helps to fix in mind a principle that is of practical daily use.

c. A laboratory experiment justifies its existence only when it interests and arouses the curiosity of the student.

d. If possible, all laboratory experiments should consist in the study of simple machines similar to those which are actually used outside of the laboratory: *e. g.*, cranes, derricks, hoisting engines, hydraulic machinery, small water motors, toy hot air engines, toy gas engines, toy steam engines, toy motors, etc.

7. In your opinion what is most needed to make physics more interesting, stimulating, and inspiring to the students and more useful as an educative factor?

8. Can you justify all the experiments for which you have

voted in the above list? If so write their numbers under one of the following heads:

a. Experiments that have always been there, you don't know quite why.
b. Experiments that teach principles which the average citizen should know.
c. Experiments that teach principles which none but an expert physicist cares to know—physics curios, as it were.
d. Experiments that interest and stimulate the curiosity of the students.
e. Experiments that stimulate the student to investigate further on his own account.
f. Experiments given for other reasons together with their justification.

Answers should be addressed to C. R. Mann, Ryerson Laboratory, University of Chicago. They should be sent in not later than March 15, at which time the results will be tabulated. Those who send answers will receive the tabulated results together with further questions which the results may suggest. We sincerely hope that everyone will join in this move and add his vote for the purpose of helping each other in making our truly great subject inspiring to the youth of this country.

C. R. MANN, University of Chicago.
C. H. SMITH, Hyde Park High School, Chicago.
C. F. ADAMS, Central High School, Detroit.

REPORT OF THE COMMITTEE ON "A STRAIGHT LINE IS THE SHORTEST DISTANCE OR PATH BETWEEN TWO POINTS."

[At the meeting of the Mathematical Section of the Association of Ohio Teachers of Mathematics and Science, March 25, 1905, Professor Halsted read a paper on "How to Teach Rational Geometry." At the conclusion of this paper the following resolution was offered: *Resolved,* That in teaching demonstrative geometry we will not use the phrase "A straight line is the shortest distance or path between two points;" or the phrase "The shortest distance between two points is measured on the straight line joining them." This resolution was referred to a committee, elected by the Section, with instruction to report at the next meeting. This committee, composed of Professor Halsted, President Howe and Professor Wilson, reported at the meeting of the Section, December 28, 1905, as below: The report was adopted.]

Your committee beg leave to report as follows:

(1) We believe that it is self-evident that one side of a triangle is less than the sum of the other two; however Euclid I: 20 shows that it is not necessary to make this assumption.

(2) That the shortest course from one point to another in Euclidean space lies along a straight line is a proposition which in ultimate analysis involves concepts not contemplated in its original statement as an assumption of elementary demonstrative geometry. Consequently the ground is left in better shape for future progress if this proposition is not assumed in Elementary Geometry.

(3) Both clearness and simplicity demand that the most fundamental of distinguishing properties shall be chosen as the basis of a definition. The fundamental notion in a straight line is qualitative, thus the mind first grasps and most easily comprehends it, and such is certainly the property on which the definition should rest. The fact that the notion of a minimum is somewhat complex in itself, and that in some cases of discontinuity or hyperspace the notion of minimum length is inapplicable to the straight line makes it desirable to avoid the idea of a minimum in defining a straight line or in a fundamental assumption. The particular way in which the qualitative property shall be used in the definition of a straight line is a matter open to individual choice.

[Signed] G. B. HALSTED, *Chairman*,
C. S. HOWE,
W. H. WILSON.

THE MEANING AND USE OF THE THREE-PLACE TABLE. (III.)

By G. W. Myers.
The University of Chicago.

The numbers (No.) of this table, that lie between 10 and 100, all have two digits left of the decimal point. The table of page 104 shows that all such numbers have logarithms that lie between 1 and 2. These logarithms must, then, all be 1 + *some proper fraction.* Define a proper fraction. Give illustrations. *Only the fraction is given in the table.* It is understood *that the 1 must be written before the fraction given in the table to obtain the complete logarithm.*

Again, the table on page 104 shows that the fractional part of the logarithm of a number between 10 and 100 is the same as the fractional part of the logarithms of numbers denoted by the same digits, but lying between 1 and 10, 100 and 1000, 1000 and 10000 and so on. The teacher will select suitable numbers from the table to make this clear. The fractions of this table will then serve for the fractional part of the logarithms of any numbers greater than 1. The whole, or integral, part of the logarithm (called *the characteristic*) must be found by noticing between what two adjacent perfect powers of 10 the *number* lies, whose logarithm is sought. The teacher will make this plain by a number of illustrations.

To be clear as to the meaning of the table let it be borne in mind that the 255 in the second column (headed O) and in the horizontal line with 18 means that $10^{1.255}=18$ and that the 267 in the column headed .5 means that $10^{1.267}=18.5$, and so forth. Such an equation of $10^{1.255}=18$, or $10^{1.267}=18.5$ may be called an explanatory equation of log $18=1.255$, or log $18.5=1.267$. The teacher will make this clear by other illustrations drawn from the table.

QUESTIONS.

1. Show by the table what the complete logarithm of 47 is and write the *explanatory equation.*

2. Show the complete logarithms and write the explanatory equations for the following:

35; 49.5; 54; 59; 68.5; 73; 86.5; 97.5.4; 9

3. To find the logarithm of the product of 67×48.

Solution: $48 = 10^{1.681}$
$67 = 10^{1.826}$

multiplying, $48\times67 = 10^{1.681}\times10^{1.826} = 10^{3.507}$, just as $10^2\times10^3 = 10^{2+3} = 10^5$.

The logarithm of the product of 48 and 67 is 3.507. This illustrates that the logarithm of a product is the *sum of the logarithms of the factors.* The teacher should illustrate this further.

4. Find the logarithms of the following products:

37×59; 69×52.5; 84×88.5; 17×78.5; $45\times28\times15$; $16\times39\times48.5$.

5. Find the quotient of $68\div19.5$.

Solution: $68 = 10^{1.832}$
$19.5 = 10^{1.290}$

Dividing, $68\div19.5 = 10^{1.832} \div 10^{1.290} = 10^{.542}$, just as $10^5 \div 10^2 = 10^{5-2} = 10^3$.

The logarithm of $68\div19.5$ is .542 ($=1.832-1.290$). This illustrates that the logarithm of a quotient equals the logarithm of the dividend *minus* the logarithm of the divisor.

6. Find the logarithms of the following quotients:

$53\div27$; $48\div13.5$; $87.5\div24.5$; $98.5\div14.5$; $71.5\div49$.

7. Find the logarithm of the square of 37.5.

Solution: $37.5 \times 37.5 = 10^{1.574}\times10^{1.574} = 10^{2\times1.574} = 10^{3.148}$.

The desired logarithm is 3.148, which is *twice* the logarithm of 37.5 This illustrates that the logarithm of a power equals the logarithm of the *base* times the *exponent* of the power.

8. Find the logarithm of the cube of 37.5.

Solution: $37.5 \times 37.5 \times 37.5 = 10^{3\times1.574} = 10^{4.722}$, just as $10^2\times10^2\times10^2 = 10^{3\times2} = 10^6$.

9. Find the logarithms of the square, the cube and the fourth power of the following:

16.5; 36.5; 98; 71; 68.5; and 99.5.

10. Find the logarithm of the square root of 33.

Solution: Let x denote the desired logarithm of the square root of 33. Then $10^x\times10^x = 33$. But $33 = 10^{1.518}$ and $10^x\times10^x = 10^{2x}$. Then $10^{2x} = 10^{1.518}$. This can be true only by making $2x = 1.518$ or $x = .759$, the desired logarithm.

NOTE.—The teacher should have several such logarithms of selected tabular numbers found and should then bring out the following principle. ***Principle*—The logarithm of the square root of any number is ½ of the logarithm of the number.**

In a similar way develop the principles for finding the logarithms of the cube root and of the fourth roots of numbers.

Then generalize a method for other roots and test the generalized method by problems.

Such a study of logarithms as the foregoing may profitably occupy six or seven recitations of a fair eighth grade class, or 2 or 3 weeks of a first year high school class.

Let us see how the logarithms of some numbers may be found from the logarithms of other numbers.

$4 = 2\times 2 = 10^{0.3010} \times 10^{0.3010} = 10^{0.3010+0.3010} = 10^{0.6020}$

$\therefore \log 4 = 0.6020$.

$6 = 2\times 3 = 10^{0.3010} \times 10^{0.4771} = 10^{0.3010+0.4771} = 10^{0.7881}$

$\therefore \log 6 = 0.7781$.

$9 = 3\times 3 = 10^{0.4771} \times 10^{0.4771} = 10^{0.4771+0.4771} = 10^{0.9542}$

$\therefore \log 9 = 0.9542$.

$14 = 2\times 7 = 10^{0.3010} \times 10^{0.8451} = 10^{0.3010+0.8461} = 10^{1.1461}$

$\therefore \log 14 = 1.1491$.

$10 = 2\times 5 = 10^{0.3010} \times 10^{0.6990} = 10^{0.3010+0.6990} = 10^{1.0000}$

$\therefore \log 10 = 1.0000$ (as we know).

$126 = 9\times 14 = 10^{0.9542} \times 10^{1.1461} = 10^{0.9542+1.1461} = 10^{2.1003}$

$\therefore \log 126 = 2.1003$.

Log 2 = 0.3010; log 3 = 0.4771; log 5 = 0.6990; log 7 = 0.8541; log 11 = 1.0414; log 13 = 1.1139.

Find the logarithms of the following numbers:

(1) 6; (2) 9; (3) 4; (4) 8; (5) 12; (6) 14; (7) 15; (8) 21; (9) 35; (10) 33; (11) 42; (12) 26; (13) 39; (14) 55; (15) 77; (16) 65; (17) 143; (18) 30; (19) 70; (20) 105.

Show how to divide numbers by logarithms.

(1) $\frac{18}{3}$; (2) $\frac{36}{12}$; (3) $\frac{165}{15}$; (4) $\frac{143}{11}$.

Show how to find the square, cube, 4th, 5th, etc., by logs.

$\sqrt{16}$; $\sqrt[3]{27}$; $\sqrt{64}$; $\sqrt{144}$; $\sqrt[3]{1728}$; $\sqrt{628}$; $\sqrt[3]{180}$.

Here show how numbers may be roughly interpolated from the 3-place table. Make the process clear with the simple 3-place numbers. Then pass to the use of a standard 4-place table, if thought best.

Problems for logarithms.

Multiplication.

1. A lot is 24'. 8x120'.6; how many square feet are there in it?
2. A field is 38.4 rd. x62.8 rd., how many square rd. in it?

A street car averages 18 trips a day, carrying 36 paid pas-

sengers a trip at 5 cts. a fare for 28 days of a month. What amount of money is taken in on this car during the month?

Log 2=0.3010; log 3=0.4771; log 7=0.8451.

4. How many cubic feet in a box 2'.5x3'.6x4'.2?

5. How many cu. yd. in a room 4.6 yd.x5.5 yd.x13.3 yd.?

6. How many cu. ft. in the room of problem 5?

7. How many cu. ft. in a wagon box 2'.9x3'.5x10'.2?

8. Water weighs 62.5 lb. per cu. ft. and copper is 8.8 times as heavy. How heavy is a mass of copper 2.'5x3.'7x4.'3?

9. Ice weighs .92 as much as an equal bulk of water. How much does a mass of ice 6'x10'x40' weigh?

10. What will it cost to pave a street 24 yards wide a distance of 1 mile at $4.78 per square yard?

Division.

1. How many sq. yd. in the lot of problem 1?

2. How many acres in the field of problem 2?

3. Find the weight in ounces of a cu. in. of iron, a cu. ft. weighing 487.5 pounds.

4. How many bu. of small grain will the wagon box of problem 7 contain? (1 bu.=1.2 cu. ft.)

5. How many bu. of ear corn will the wagon box of problem 7 contain? (1 bu.=2.5 cu. ft.)

6. How many bu. of ear corn will a crib 12'×16'.2×40'.4 hold? (2.5 cu. ft.=1 bu.)

7. A cu. ft. of steel weighs 490 lbs. Find the weight of a cubic inch. How many cubic feet will weigh 1 ton (2000 lbs.)?

Involution.

1. How many cubic feet in 5-ft. cube? In an 8-ft. cube? In a 16-ft. cube? etc.

2. How many cubic feet are there in a 4.5 ft. cube? In a 7.6 ft. cube? In a 24.6 ft. cube?

3. How many cubic inches are there in a 36".5 cube? in a 58".6 cube? in a 63".7 cube?

Evolution.

1. Find the length of the edge of a cube whose volume is 216 cu. ft.? 343 cu. ft.? 729 cu. ft.?

2. Find the approximate length of an edge of a cube whose volume is 74.09 cu. ft.? 1092.73 cu. ft.? 4330.75 cu. ft.?

3. Find by logarithms approximately the length of one side of the following squares:

(1) 104.04 sq. ft.; (2) 357.21 sq. ft.; (3) 384.16 sq. ft.; (4) 1004.89 sq. ft.; (5) 1497.69 sq. ft.

At this point with a grade class, that is without a working knowledge of negative numbers, I should stop. But with a first year high school class the subject should be continued into and through the meaning and use of *negative* logarithms. This may be done by continuing upward the lists of numbers in geometrical ratio and the corresponding numbers of the arithmetical series. The customary method of writing the negative logarithm must be carefully explained.

In conclusion, attention is here drawn to the fact that logarithms were long studied under the aspect of an arithmetical series of numbers whose terms maintained a correspondence one by one, to the terms of a geometrical series, as is given above. The history of the development of the subject is, therefore, favorable to the mode of procedure proposed above as a rudimentary treatment. The real teacher will not object to the proposed plan because there still remain many things to be learned about logarithms.

State Normal College, Ypsilanti, Mich., an. 16, 1906.

EDITOR OF SCHOOL SCIENCE AND MATHEMATICS:

Will you kindly allow me space in your valuable journal for a single inquiry?

Precisely where does La Place say that "the earth and the other planets originally were masses of molten matter thrown off from the sun by its whirling motion," as Professor Chamberlain is reported, on page 73 of the January issue, to have said? Surely not in his famous Scholium. And why oppose Professor Chamberlain's extremely interesting and promising speculation to a nebular hypothesis—that of La Place or any one else? Is it not itself one of the many forms of a nebular hypothesis? That is, does it not strive to rationalize the diverse forms of the universe, even those as far apart as a nebula and a well ordered solar system, and bring them into a harmonious whole?

I cannot close this note without calling attention to the remarkably broad and thorough treatment of this general subject in the British Association presidential address of George Darwin in South Africa last summer. Very truly yours,

E. A. STRONG.

TROPICAL FRUITS.

By Mel T. Cook,

Chief of the Division of Vegetable Pathology of the Cuban Agricultural Experiment Station.

IX.—Guava.

Probably no one article of food in tropical America has so justly attracted more attention than the guava jelly which is so much enjoyed by both natives and visitors. The fruit from which this jelly is made grows wild and there has been little or no effort to cultivate it. The tree, or rather bush, is 15 or 20 feet in height and is known by the common name of guayava, which has

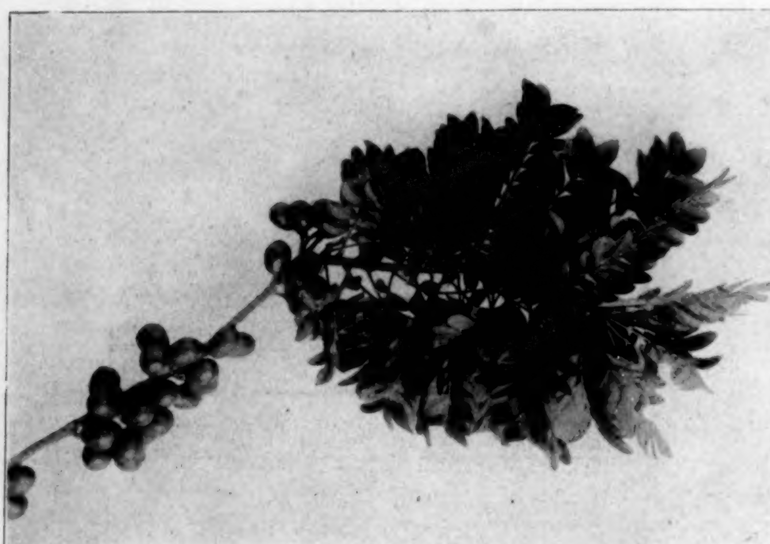
PERUVIAN GUAVA.

been modified in English into guava. It belongs to the family *Myrtaceae* and is known to science as *Psidium guajava.* The flowers are white and very much resemble apple blossoms, except that they are not so numerous or showy. The fruit is spherical with a thick, fleshy rind and a very large number of small seeds. It varies greatly in size, color of flesh and flavor in the countless number of seedling varieties.. The Peruvian variety is quite large, pear shaped and not subject to such great variation as the native Cuban varieties.

X.—CIRUELA.

This fruit, which is also known as bog plum and jobo (pronounced hobo), belongs to the same family *(Anacardiaceae)* as the mango and maranon referred to in the December number. The most common sptcies is *Spondias lutea,* which is a tree 40 feet or more in height and with a soft brash wood. It is easily propagated from cuttings and is extensively used for living fence posts. The fruit is plum-like, oval, about 1½ inches in length, yellow, with a thin skin, large nut-like seed and a small amount of pleasantly flavored pulp. It is not of much value except in the local markets.

The other species is *S. purpurea,* which is a much smaller tree.



CIRUELA.

It has been introduced into the West Indies from South America. The fruit is purplish red and said to be much better flavored that *S. lutea.* It is usually grown in gardens for the fruit only.

XI.—MAMONCILLO.

This tree, which is known by the above name in Cuba, and by the name of genepe in Porto Rico, probably has the most pleasant flavor of any of the tropical fruits. It belongs to the family *Sapindaceae* and is also supposed to have been introduced into the West Indies from South America. It is known in botany as *Melicocca bijuga.* It is a very beautiful tree and produces a

spherical fruit about one inch in diameter. The fruit is covered with a thick, leathery, green skin and contains a very large seed and a very small amount of very pleasantly flavored pinkish pulp. It also contains numerous small fibers which are said to some-

MAMONCILLO.

times produce very disagreeable sensations in the stomach. The bulletin of the Jamaica Botanical Department states that these fibers have caused the death of children. This fruit is known only in the local markets, where it is sold in bunches of twigs, to which the fruit is attached.

WHAT AND HOW MUCH CAN BE DONE IN ECOLOGICAL AND PHYSIOLOGICAL ZOOLOGY IN SECONDARY SCHOOLS?

By Oscar Riddle,

Central High School, St. Louis, Mo.

Every teacher of Zoology in secondary schools must, for the present at least, consider two distinct orders of problems; first the problems of the science itself; and second, the problems of teaching the science. Happy would we be, if our undivided thought might serenely rest upon the former group alone; if we might, with nothing to distract, pass our days in thinking and examining the countless problems of life phenomena. But such happiness is not yet for the zoologist of secondary schools. The very richness and many-sidedness of his science has brought to him an added care. He cannot teach all; he must select.

Problems of What, How Much, and What Method have been outlining and defining themselves for several years. There has been, however, little trace of unanimity in the solutions given to them. The subject matter, the content of the course in zoology today differs, as we all know, very widely in the different schools. I believe that we all recognize then, that the present lack of uniformity should, and probably will, soon give way to a more settled order of things; and that it is, too, within the bounds of probability that certain phases of our subject may be more used and more useful in the future than they have been in the past.

We have, therefore, a common interest in the problems,—What and How Much Ecological and Physiological Zoölogy can be taught in Secondary Schools? When I was asked to speak on this subject, I consented because I felt sure of your interest in the subject, if not in the substance of my paper. And I want to state just here that I know of no reason why I was asked to furnish this paper. I can hardly even claim to be teaching Zoology. In St. Louis no course in Zoology is offered. A course in Physiology, chiefly laboratory work, is given instead. In the physiological work, however, it is our aim to give not merely a course in human physiology, but to teach what we choose to call zoological physiology. It is then not physiological zoology but zoological physiology with which I am concerned in my own work.

But whether we have or have not a common approach to the subject in hand, a common point of view from which our perspective is the same, I want you to review with me first some facts as I see them, regarding the nature and scope of the physiological zoology of the present. I must not launch myself into this subject, however, without at the outset making a ready acknowledgment that I am acutely conscious of the fact that I have not been able to answer the questions which are stated in my subject. He who does that will make a real contribution to the pedagogy of Zoology. In the race for such an honor, I am very certain that I cannot even qualify.

The very most that I can do, therefore, is to ask you to review our present work—and first our physiological work,—with one who is prejudiced to the view that more should be done, but who thinks he has seen in his own experience that more can be done.

It seems necessary to preface such a review with a word concerning the aim in zoology teaching. In what I shall say here about What and How Much of any phase of Zoology shall be taught, I am taking it for granted that our aim in Zoology teaching is to give the best possible scientific training, along with information regarding the essential facts and ideas of zoology. I shall not attempt to justify or defend this aim, but I will state that a more vague or less pretentious aim will fail to put zoology on an equal footing with the other sciences taught in secondary schools. It must not attempt less, if, in the minds of the students themselves, it is to share an equal dignity with chemistry and physics.

Let us now turn to our main discussion,—the place of physiology in zoological work. I want to point out in this connection three or four representative and specific cases in which I shall give my general idea of what and how much should be done, and why our present work is inadequate.

For the first example I choose the *cell.* We all teach the general morphology of the cell; at least such evident and nearly constant structures as nucleus, protoplasm, and cell-wall. But, how often do we develop anything like an adequate idea of the functions of these parts? How much time do you devote, and how many preparations and experiments do you use to show the work of the nucleus? How much are you doing to make clear the role of the cell-wall in cell activities? Should we not do

some simple work to establish in the mind of the student the importance and activity of the nucleus in heredity, oxidation and cell-divisions? Should we not perform some experiments in osmosis, surface tension, et cetera, in order to give him an idea of the nature of the cell membrane, its relation to the cell-contents, and to the external world?

Here I maintain that we are not sufficiently associating structure and function. I cannot think that these structures, ultimate units though they are, can have a proper significance without a knowledge of their functioning. When on the other hand he has done some such work as that indicated above, the student has a body of facts which he can apply to any and all the structural units of the organic world. We can neither excuse ourselves on the ground of difficulties in demonstrating these facts, nor of the lack of sufficient facts. Some simple preparations and experiments will make these functions clear, and there is a mountain of facts of cell physiology. Eleven years ago Verworn had difficulty in considering even the important facts and principles of "cell physiology" in a book of 600 pages.

As our second example, let us consider the nature of our study of the *heart*. In nearly all of our animal types there is a heart, and in each type we call attention to its position, size, shape, compartments, walls, its relation to the great blood vessels, and compare it with other hearts already studied. But what about its physiology? Of course the student is told, and perhaps sees, that the heart pumps the blood, that the valves keep it from flowing backward, and that the ventricle—when present—furnishes the force for keeping the blood in motion. But this, in my opinion, is merely avoiding the physiology of the heart. It is as incomplete as the morphological study would be if we stopped with finding the position and shape of the heart. The one study is as empty and hollow as the other. The important morphological fact of a heart is its *structure* and its *homologies* as found elsewhere; this the student gets. The important physiological fact of a heart is the answer to the questions: *Why does it beat? What is the source of its activity?* And this the student does not get.

I will support my assertion that this is the character of much work done, or at any rate, that it is the character of the work outlined in many of our text books, by a complete statement of the work on the heart as it is outlined in one of them. The

text to which I refer, is a popular and representative one which covers in detail the laboratory work; and, indeed, in some respects it is a good book.

In the directions for the study of the fish I find the following:—"Turn now to the peritoneal cavity and examine the heart The red angular portion of the heart which, in the natural position of the fish, lies lowest and hindmost is the ventricle; the darker more irregular portion lying (in the natural position) above the ventricle is the auricle; the larger blood cavity back of the auricle and extending across the body cavity, above the false diaphragm, is the venous sinus; in front of the ventricle is the light-colored, conical, arterial bulb. This narrows forward into an artery which gives off branches on both sides, one to each gill. Make a drawing of the heart and arterial bulb." But not *one* word is said on the physiology of the heart.

In previous parts of the book the hearts of three invertebrates are studied morphologically, with *no* reference to function. Moreover, the hearts of four other vertebrate types are studied. In one of these—the mammalia—eight entire and compact pages are given to a study of the heart and blood vessels, and the only physiological fact concerning the heart, which is mentioned here and indeed in this entire book is a statement of the action of the valves in the heart of the mammal.

Now, my fellow teachers, I want to go on record as one who declares such a treatment of such an organ as outrageously deficient and distorted.

When a pupil takes a dead, anaesthetized frog, and proves the automatic nature of the heart-beat by removing the heart and noting its continued beat; and when he finds by experiment—pinching the vagus, tapping or stroking the viscera, for example—the influence of the vagus upon the heart, then, the heart and the vagus have acquired a new meaning for him. Indeed, he then knows the most important physiological fact of the heart of every vertebrate, and perhaps, too, of most invertebrates.

Compare the effect on the student, and the value to him, of such a study of the source of the heart's action, with such an investigation as—"the darker more irregular portion lying (in the natural position) above the ventricle is the auricle; the larger blood cavity back of the auricle, and extending across the body cavity, above the false diaphragm, is the venous sinus; in front of the ventricle is the light-colored, conical, arterial, bulb."

Who among the teachers here assembled can remember the relations of parts in one-fourth of the dissections he has made? If there is such a person among us he should be given a medal—but who among us has performed the experiment to show the automaticity of the heart, and has forgotten the result? If there is such a teacher among us he should throw up his job!

There is a wonderful difference in the way these two sets of facts affect our students; the former come to be learned—and forgotten—with mechanical precision; the latter, when properly presented arouse a great and immediate human interest. The problem is scarcely stated before the student has a direct, personal interest in solving it.

Recently it was demonstrated to me that the interest in this particular experiment will at any rate outlast the laboratory period. We had, in the laboratory, considered only the question of the extrinsic or intrinsic origin of the heart beat, but on the following day a boy of 14 years ventured the remark that though we had proved that the source of the heart-beat was within the heart itself, that according to his book which he had consulted a few pages in advance, it is still not known whether it is the heart muscle itself which starts the motion, or the nerve cells in the heart that does this. He had, as you see, both the interest and intelligence to grasp the problem of the neurogenic or neyogenic origin of the heart-beat, which has for many years been one of the real problems of physiology. This class was then told some evidence for each of the views mentioned above; and finally we reviewed Carlson's recent work on the King Crab, Limulus, in which animal, he was able, owing to the peculiar separation of the nervous and muscular parts of its heart, to prove that the heart-beat, in Limulus at least, is of nervous, not of muscular origin. I have noted that from that time the members of the class have shown an added interest in Limulus. Indeed, the fact that the clumsy King Crab has apparently furnished the solution of a problem in which they were much interested, made these animals for several days the most popular objects in my laboratory.

(*To be continued.*)

PROBLEM DEPARTMENT.

PROFESSOR IRA M. DELONG,
University of Colorado, Boulder, Colo.

Readers of the Magazine are invited to send solutions of the problems in this department and also to propose problems in which they are interested. Solutions and problems will be duly credited to the author. Address all communications to Ira M. DeLong, Boulder, Colo.

ALGEBRA.

1. A and B start to run a race to a certain post and back again. A returning meets B at 90 yards from the post and arrives at the starting-place 3 minutes before him. If he had returned immediately to meet B, he would have met him at one-sixth of the distance between the post and the starting-place. Find the length of the course and the duration of the race.

I. ***Solution by A. B. Warren, Westerly R. I.***

This solution is on the understanding that the second condition means one-sixth of the distance from the post.

Let x = distance from starting point to post; y = A's time for running the entire course 2x; then $\frac{2x}{y}$ = A s rate; $\frac{2x}{y+3}$ = B's rate.

From the first condition $\dfrac{x+90}{\frac{2x}{y}} = \dfrac{x-90}{\frac{2x}{y+3}}$, whence $x = 90 + 60y$.

From the second condition $\dfrac{2x+\frac{5}{6}x}{\frac{2x}{y}} = \dfrac{x+\frac{x}{6}}{\frac{2x}{y+3}}$

Solving, $x = 216$, $2x = 432$, $y = 2\frac{1}{10}$.

Solved on the same interpretation by J. B. G. Welch, Emma Hyde, T. E. Vaughan, H. H. Seidell.

II. ***Solution by Homer Derr, B. S., Mt. Pleasant, Mich.***

This solution is on the understanding that the second condition means one-sixth of the distance from the starting point.

Let x = distance to post, *i. e.*, half the length of the course; y = A's time to run 2x, then

$$\frac{\text{A's rate}}{\text{B's rate}} = \frac{x+90}{x-90} = \frac{y+3}{y} = \frac{2x+\frac{x}{6}}{2x-\frac{x}{6}} = \frac{13}{11},$$ from which $x = 1080$, $y = 16\frac{1}{2}$.

Solved on the same interpretation by E. L. Brown, R. S. Pond, Carl Ackermann, Pearl Colby Miller, I. L. Winckler, E. A. Peabody, L. J. Hopkins, Louise Nicholson.

Two incorrect solutions were received.

2. Solve $$\frac{(1+x)^{\frac{1}{2}}-1}{(1-x)^{\frac{1}{2}}+1} + \frac{(1-x)^{\frac{1}{2}}+1}{(1+x)^{\frac{1}{2}}-1} = a$$

Solution by Pearl Colby Miller, M. A., St. Louis, Mo.

Rationalizing each denominator we obtain $(1+x)^{\frac{1}{2}}+(1-x)^{\frac{1}{2}} = \frac{ax}{2}$.

Squaring, these results $(1-x^2)^{\frac{1}{2}}=\frac{a^2x^2}{8}-1$, whence $a^4x^4-16a^2x^2+64x^2=0$.

This gives $x = \pm \frac{4}{a^2}(a^2-4)^{\frac{1}{2}}$, $x = 0$. The value $x = 0$ makes the left-hand side of the given problem take the form $\frac{0}{0}+\frac{0}{0}$ if the negative value of $(1-x)^{\frac{1}{2}}$ and the positive value of $(1+x)^{\frac{1}{2}}$ are taken.

Also solved by Emma Hyde, E. L. Brown, P. H. Hildebrandt, Alex. Crawford, I. L. Winckler, J. B. G. Welch, T. E. Vaughan, Grant Grumbine, R. S. Pond, E. S. Spafford, C. A. Peabody, L. J. Hopkins, Louise Nicholson, H. C. Whitaker, H. H. Seidell.

3. Reduce into simple or partial fractions

$$\frac{6x^2-4x-6}{(x-1)(x-2)(x-3)}$$

Solution by I. L. Winckler, Cleveland, Ohio.

Let $\frac{6x^2-4x-6}{(x-1)(x-2)(x-3)}=\frac{A}{x-1}+\frac{B}{x-2}+\frac{C}{x-3}$

Then $6x^2-4x-6\equiv A(x-2)(x-3)+B(x-1)(x-3)+C(x-1)(x-2)$, whence $A=-2$, $B=-10$, $C=18$.

Also solved by Emma Hyde, R. S. Pond, E. L. Brown, Eleanora Harris, Grant B. Grumbine, Carl Ackermann, P. S. Berg, Ella M. Briggs, Pearl Colby Miller, T. H. Hilderbrandt, E. G. Spafford, C. A. Peabody, L. J. Hopkins, Louise Nicholson, H. C. Whitaker, H. H. Seidell.

The following solutions were received too late for crediting in the February number: H. E. Cobb: 1b, 4, 6, 8, 9; I. L. Winckler: 1a, 1b, 2, 3 of December.

GEOMETRY.

4. From a given point between two given straight lines draw a straight line which shall be terminated by the given lines and bisected at the given point.

Solution by T. H. Hildebrandt, Chicago, Ill.

Let AB and CD be the lines meeting at O, and P the given point. Draw OP and continue it to Q so that OP=PQ. From Q draw lines parallel to AB and CD, forming with AB and CD a parallelogram of which OQ is one diagonal. The other diagonal is the required line. If the two given lines are parallel the problem is impossible unless P is midway between AB, CD.

Also solved by Eleanora Harris, W. D. Higdon, Carl Ackermann, Pearl Colby Miller, I. L. Winckler, E. L. Brown, R. S. Pond, Emma Hyde, J. B. Merrill, G. B. Grumbine, J. Alexander Clarke, P. S. Berg, Ella M. Briggs, A. W. Massey, E. G. Spafford, C. A. Peabody, Louise Nicholson, J. H Morgan, H. H. Seidell.

5. If ABC be a triangle with the angles B . C, each double of the angle A, prove that $\overline{AB}^2=\overline{BC}^2+AB\,.\,BC$.

Solution by J. Alexander Clarke, A.M., Philadelphia, Pa.

Let the bisector of the angle B meet AC in D; then the angle ABD = A = CBD and angle CDB = C. Therefore AB = AC and AD=BD=BC.

The triangles ABC and BCD are similar and therefore

$\frac{BC}{AB}=\frac{CD}{BC}$. By composition, $\frac{AB+BC}{AB}=\frac{BC+CD}{BC}$ and therefore

$\frac{AB+BC}{AB}=\frac{AD+CD}{BC}=\frac{AC}{BC}=\frac{AB}{BC}$. Consequently $\overline{AB}^2=\overline{BC}^2+AB\,.\,BC$.

Also solved by I. L. Winckler, R. S. Pond, Eleanora Harris, C. Ackermann, G. B. Grumbine, P. S. Berg, W. D. Higdon, Pearl C. Colby, Ella M. Briggs, B. Watson, T. H. Hildebrandt, J. B. Merrill, E. L. Brown, C. A. Peabody, Louise Nicholson, H. C. Whitaker, H. H. Seidell, J. B. G. Welch.

TRIGONOMETRY.

4. *Proposed by P. E. Graber, Akron, Ohio.*

In a sperical triangle if $A<90^\circ$ and $C=90^\circ$, prove that $b-c<90^\circ$.

Solution by H. C. Whitaker, Ph. D., Philadelphia, Pa.

By Napier's Rule, $\tan b=\tan c \cos A$.

Since $\cos A$ is positive by hypothesis, $\tan b$ and $\tan c$ have the same sign and are therefore in the same quadrant. Therefore their difference is less than 90°.

Also solved by H. B. Seidell, I. L. Winckler.

MISCELLANEOUS.

2. *Proposed by F. C. Donecker, Chicago, Ill.*

A ball 12 inches in diameter is rolled around a circular room 12 feet in diameter in such a way that it always touches both wall and floor. How many revolutions does the ball make in rolling once around the room?

I. *Solution by E. L. Brown, M. A., Denver, Colo.*

We will consider two special cases: (a) when the ball rotates about its vertical axis, and (b) when it rotates about its horizontal axis through the point of contact with the wall.

a) Let O be a point on the axis of the cylindrical room at the height of 6 inches above the floor. Let C_1 be the initial position of the center of the ball, A_1 the initial point of contact of ball and wall. Let C_2 be the position of the center when the point A_1 of the ball is again in contact with the wall (at the point A_2). This will occur for the first time after the ball has travelled $\frac{1}{12}$ the way around the room, since the circumference of the room is 12 times that of ball. Iu this case, angle A_1OA_2 equals 30°, and, therefore, in going $\frac{1}{12}$ the distance around the room, the diameter A_1C_1 has turned through an angle of 330°, so that the ball has made $\frac{11}{12}$ of one rotation. Therefore, in making one complete revolution around center of room, the ball will rotate about its axis eleven times.

b) The number of rotations in the second case is the ratio of the circumference of circle with radius OC_1 to that with radius C_1A_1; that is, as 11π is to π. Hence, as in first case, the ball will rotate about this axis eleven times.

Solved as in (b) by H. C. Whitaker, H. H. Seidell, Sadie H. Nelson.

II. *Solution by H. B. Leonard.*

Assume that the ball in its initial position touches the wall at M and

the floor at N and let O be the center of the circular floor. Let ON intersect the wall at P.

In the plane MNO, let MN intersect the axis of the cylindrical room OQ at Q. Let C be the center of the ball. Draw MS and NR perpendicular to QC.

By similar triangles $\frac{PO}{NO} = \frac{QM}{QN} = \frac{SM}{RN} = \frac{6}{5\frac{1}{2}} = \frac{12}{11}$. The triangles CSM and NRC are equal and CS = RN.

$$\frac{12}{11} = \frac{SM}{CS} = \tan SCM = \tan 47^\circ\ 29'\ 23''.3;$$

$$2\ \overline{MS} = 0.73717 = \qquad \sin 47^\circ\ 29'\ 23''.3,$$

$$2\ \overline{NR} = 0.67572 = \qquad \cos 47^\circ\ 29'\ 23''.3.$$

Consider the ball as turning around the axis QC. As it rolls, this axis always passes througn Q and the ball touches the wall along the circle through M and the floor along the circle whose radius is ON.

The circumference of the small circle of the ball that rolls on the floor circle of contact is $2\pi\overline{RN}$ or 0.67572π feet. The circumference of the floor circle of contact is 11π feet.

$\frac{11\pi}{0.67572\pi} = 16.2789$ turns rround the axis QC and once around the axis OQ.

Solved with the same result by P. S. Berg, P. G. Agnew.

PROBLEMS FOR SOLUTION.

ALGEBRA.

11. *Proposed by E. L. Brown, M. A., Denver, Colo.*

$$1^p + 2^p + 3^p + \ldots\ldots + n^p = \frac{n^{p+1}}{p+1} + \frac{p}{1!}(1^{p-1}+2^{a-1}+\ldots\ldots+n^{p-1})$$
$$-\frac{p(p-1)}{3!}(1^{p-2}+2^{p-2}+\ldots\ldots+n^{p-2})\ldots\ldots \pm \frac{p}{2!}(1^2+2^2+\ldots\ldots n^2)$$
$$\mp(1+2+\ldots\ldots+n) \pm \frac{n}{p+1},$$ p being a positive integer.

GEOMETRY.

13. *Proposed by I. L. Winckler, Cleveland, Ohio.*

A series of circles tangent to a given straight line at a given point in the line intersect a given circle. Show that the common chords of the given circle and the series of circles pass through the same point.

14. *Proposed by W. D. Higdon, St. Louis, Mo.*

If the bisectors of two angles of a triangle are equal the triangle is isosceles. (Preferred, a direct geometrical proof.)

15. *Proposed by P. S. Berg, Larimore, N. D.*

If P be the point of intersection of the medians of a triangle ABC, and Q any other point in the plane, then—

$$\overline{QA}^2+\overline{QB}^2+\overline{QC}^2=\overline{PA}^2+\overline{PB}^2+\overline{PC}^2+\overline{3PQ}^2.$$

TRIGONOMETRY.

13. *Proposed by I. L. Winckler, Cleveland, Ohio.*

On the bank of a river there is a column 200 feet high supporting a statue 30 feet high. The statue to an observer on the opposite bank subtends an equal angle with a man 6 feet high standing at the base of the column. Find the breadth of the river.

DEPARTMENT OF METROLOGY. NOTES.

MASSACHUSETTS CHAIN MEASURE STANDARD.—The Old Bay State is the pioneer in a fixed reference standard for line, tape and chain measure which is lengthy, and accessible. The standard has only just been installed at the State House in Boston, the triangular case containing it being firmly fastened to the wall in one of the upper corridors. The metallic plate is 50 feet (15.24 m) in length, 2 in. (5.08cm.) in breadth and .5 in. (1.27cm) thick, and is of specially constructed steel (2 per cent carbon). It is graduated both to customary and metric units, being provided with plugs of iridio-platinum set into the surface on which certain lines are ruled. This is the first public standard of the kind, and comparisons may be made without cost to the individual. Largely through the influence of Mr. D. C. V. Palmer, Deputy Sealer of Weights and Measures for the Commonwealth, the Legislature appropriated $500. for its construction. Already other states are starting similar movements. R. P. W.

THE LOWEST TEMPERATURE:—According to a French Scientific journal Prof. Olzewsky of Cracow has approached nearer the absolute zero than any other experimenter. In attempting to liquify the element helium he obtained a temperature of—271°C, or 2° Absolute. It may be remarked that though he employed 500 cm^3 of pure helium gas he was unable, even at 2° above the absolute zero, to get any evidence of liquifaction. Prof. Dewar of the Royal Institution, London, who has shared with Olzewsky liquefaction and low temperature honors, has asserted evidence of obtaining moist helium. R. P. W.

GREGORIAN CALENDAR FOR RUSSIA:—At last Russia is to join the procession of civilized countries, and among the many reforms proposed in the dazzling Revolution in that great autocracy the substitution of the Gregorian Calendar for the old Julian one is noteworthy. Russia and Greece are the two countries that have resisted almanac reforms, owing to their Greek Church doctrine. In corresponding with the outside world it has been necessary for residents to affix double dates to letters, as Jan. 1-13. Down to Feb. 28, 1900, the Julian calendar had been for a century 12 days behind the Gregorian, but, inasmuch as 1900 was a Julian leap year, though not a Gregorian one, their February had 29 days while ours had 28, and thereafter a difference ensued of 13 days. This is all to be abolished and we are informed that the Academy of Sciences of the Muscovite dominions has submitted a plan to take 13 days from Feb. 1906, and to begin March 1, in the New Style. It remains to be seen whether the Russian peasants will resist this reform as the English laborers did in 1752, when Great Britian changed, on the ground that they were to lose so many days out of life and to be deprived of their just wages. The Academy ought to do as did the French Academy at the time of the Revolution in that country, viz., inaugurate the metric system of weights and measures. No time would seem to be so appropriate as the present. R. P. W.

IS RADIUM THE CAUSE OF THE SUN'S HEAT AND LIGHT?*

BY PROF. G. H. DARWIN.

If, as has been argued, tidal friction has played so important a part in the history of the earth and moon, it might be expected that the like should be true of the other planets and satellites, and of the planets themselves in their relationship to the sun. But numerical examination of the several cases proves conclusively that this cannot have been the case. The relationship of the moon to the earth is, in fact, quite exceptional in the solar system, and we have still to rely on such theories as that of Laplace for the explanation of the main outlines of the solar system.

I have not yet mentioned the time occupied by the sequence of events sketched out in the various schemes of cosmogony, and the question of cosmical time is a thorny and controversial one.

Our ideas are absolutely blank as to the time requisite for the evolution either according to Laplace's nebular hypothesis, or the meteoric theory. All we can assert is that they demand enormous intervals of time as estimated in years.

The theory of tidal friction stands alone among these evolutionary speculations in that we can establish an exact, but merely relative, time-scale for every stage of the process. Although it is true that the value in years of the unit of time remains unknown, yet it is possible to determine a period in years which must be shorter than that in which the whole history is comprised. If at every moment since the birth of the moon tidal friction had always been at work in such a way as to produce the greatest possible effect, then we should find that sixty million years would be consumed in this portion of evolutionary history. The true period must be much greater and it does not seem unreasonable to suppose that 500 to 1,000 million years may have elapsed since the birth of the moon. Such an estimate would not seem extravagant to geologists who have, in various ways, made exceedingly rough determinaitons of geological periods.

As far as my knowledge goes, I should say that pure geo'ogy points to some period intermediate between 50 and 1,000 million of years, the upper limit being more doubtful than the lower. Thus far we do not find anything which renders the tidal theory of evolution untenable.

But the physicists have formed estimates in other ways which, until recently, seemed to demand in the most imperative manner a far lower scale of time. According to all theories of cosmogony, the sun is a star which became heated in the process of its condensation from a condition of wide dispersion. When a meteoric stone falls into the sun the arrest of its previous motion gives rise to heat, just as the blow of a horse's shoe on a stone makes a spark. The fall of countless

*Abstract from an address delivered before the British Association for the Advancement of Science, Johannesburg, South Africa, August 30.

meteoric stones, or the condensation of a rarefied gas, was supposed to be the sole cause of the sun's high temperature.

Since the mass of the sun is known, the total amount of the heat generated in it, in whatever mode it was formed, can be estimated with a considerable amount of precision. The heat received at the earth from the sun can also be measured with some accuracy, and hence it is a mere matter of calculation to determine how much heat the sun sends out in a year. The total heat which can have been generated in the sun divided by the annual output gives a quotient of about twenty millions. Hence it seemed to be imperatively necessary that the whole history of the solar system should be comprised within some twenty millions of years.

This argument, which is due to Helmholtz, appeared to be absolutely crushing, and for the last forty years the physicists have been accustomed to tell the geologists that they must moderate their claims. But for myself I have always believed that the geologists were more nearly correct than the physicists, notwithstanding the fact that appearances were so strongly against them.

And now, at length, relief has come to the strained relations between the two parties, for the recent marvelous discoveries in physics show that concentration of matter is not the only source from which the sun may draw its heat.

Radium is a substance which is perhaps millions of times more powerful than dynamite. Thus it is estimated that an ounce of radium would contain enough power to raise 10,000 tons a mile above the earth's surface. Another way of stating the same estimate is this: the energy needed to tow a ship of 12,000 tons a distance of 6,000 sea miles at fifteen knots is contained in twenty-two ounces of radium. The "Saxon" probably burns five or six thousand tons of coal on a voyage of approximately the same length. Other lines of argument tend in the same direction.

Now, we know that the earth contains radio-active materials, and it is safe to assume that it forms in some degree a sample of the materials of the solar system; hence it is almost certain that the sun is radio-active also.

This branch of science is as yet but in its infancy, but we already see how unsafe it is to dogmatize on the potentialities of matter. It appears, then, that the physical argument is not susceptible of a greater degree of certainty than that of the geologists, and the scale of geological time remains in great measure unknown.—*Scientific American.*

A PLAN FOR A CO-OPERATIVE STUDY OF BIRD MIGRATION.

Many teachers of zoology in the secondary schools as well as teachers of nature study in the grades are interested in the birds and in their migratory activities. This interest might be increased and a more definite knowledge of migratory movements be acquired if some sort of concerted action should be undertaken by such teachers and others interested.

It is already known to many that extensive movements in the spring migration, movements which result in a number of new arrivals and a great increase in the number of individuals, are more likely to occur in connection with the approach of a "low area" of barometric pressure and its accompanying south wind. Do the migrating hordes cover a long distance of a hundred miles or more at such times and then make comparatively slow progress until the next period of low area and south wind or do they advance at a fairly uniform rate regardless of weather conditions? Do they advance more rapidly along certain migration routes than over the general area of the same latitude? Such questions as these can only be answered by a comparison of observations of a number of workers stationed in various localities.

It is possible that many of our teachers do not know of the work done in 1884 and 1885 by a large number of observers stationed at many different localities in the Mississippi Valley and working under the supervision of W. W. Cooke and Dr. C. Hart Merriam. The results were published in 1888 in Bulletin No. 2 of the Division of Economic Ornithology, United States Department of Agriculture, under the title "Bird Migration in the Mississippi Valley." The Bulletin has long been out of print and is inaccessible to many.

It seems entirely feasible to undertake a somewhat less ambitious project but yet one that may accomplish results well worth the effort and that will benefit the participants. Most of the readers know of the admirable work done in Lincoln Park, Chicago, by Mr. H. E. Walter, author of "Bird Life in City Parks." Several other observers are keeping records of bird movements in their localities and the writer has been making a careful study of the spring migration at Urbana, Ill., for the past three years.

The object of this article is to make an attempt to bring about an exchange of the data recorded at various stations so that each may have the benefit of what others are doing. As an experiment and to get the movement started, the writer asks that any who are willing shall furnish him a copy of their record of first arrivals and second appearances of all species accurately identified, and in return he will promptly supply them with his data on the same species and also as far as practicable with that from other observers who similarly respond. If enough participate to make it worth while copies of the aggregate results will be printed and supplied to participants.

A considerable number of reports from well distributed localities in Ohio, Indiana, Illinois, Michigan, and Wisconsin for the spring of 1906

would certainly furnish very useful information and incidentally stimulate the interest of those enlisting in the undertaking. It is, of course, readily apparent that practically daily observations should be made in order that the actual date of first arrival be known and also that data on merely a few best known birds, as the catbird, kingbird, purple martin, etc., will be useful as far as they go.

To all who will undertake such an exchange of data the writer, on request, will furnish blanks for monthly reports on which are printed the names of 131 species, and which are so ruled as to minimize the effort necessary to make the record.

FRANK SMITH,
University of Illinois,
Urbana, Ill.

SOME MIGRATORY BIRDS WINTERING IN SOUTH DAKOTA.

By Ellwood C. Perisho,

The University of South Dakota.

One does not need to be a scientist to take great interest in and get much profit from even a casual observation of the movements of our common well known birds. In their migrations they may not stay in our fields, or on our lawns, or in the trees of our gardens or orchards but a few hours or days, yet if we will be observing they are there long enough for us to give them a welcome and to renew old acquaintances. In the latitude of the North Central States many birds will visit us whose homes vary from the Arctic Circle to the tropics of Central or South America.

As a rule these birds come and go at regular intervals—so constant are they that a bird lover once told me that he scarcely needed a calendar to tell him the time of the year, so faithful and regular were the different birds in their passage. It is fortunate for us that the migration season is a long one—even as early as the latter part of July certain species begin to move to the south. In August others will come in from the north and linger for days with us. Great troops of these little travelers will pass by in September. In October and even as late as November many others both come and leave us. As early as the latter part of February the tide of migration begins to return. During March and April it continues. In early May it will probably reach its culmination, but will not be completed until the first of June. Thus we have only about four to five months of the year free from some bird migrations. The fall and spring months of our school year are well adapted for observation on the birds coming and going, while our winter months may be used to observe what varieties remain with us during December, January, and February.

It is not the object of this paper to give a scientific discussion concerning the time, place, or cause of bird migration, but rather to encourage careful observation on the part of those, whether students or teach-

ers, who are so fortunately situated as to be able to note both the presence and absence of our common birds.

The generally understood idea of the time of withdrawal of our more common field and orchard birds, from the north to the south does not hold good, at least not in southeast South Dakota.

Many have claimed that the real cause of bird migration was due to temperature. If this be true then why did not all our migratory birds go south on the approach of cold weather—for we had many days last year as cold as twenty to thirty degrees below zero, coming, however, as late as near the middle of January. Others say that when the time comes in the fall, no matter what the climatic condition, the birds will leave the north. Last fall, however, they did not do so, nor have they gone yet, October 15. [The trees and lawns are as green now as they were any time in the spring or summer.] The autumns in South Dakota are wonderful for their mildness and their rare beauty. Last year the grass on the university campus was green until the last of November. The leaves were not killed by frosts at all. They simply lived their allotted time and ceased to perform their functions. It was not until after our Christmas vacation that cold weather really visited this part of the state. Then came a few weeks when it was really very cold.

The following birds were often seen in October, November and December: Robins, blackbirds, bluebirds, flickers, etc. Upon my return to the university after the holidays I supposed the birds were gone. I never knew better until early in February, when to my surprise I found one day a large number of robins and bluebirds on the university campus. They were all fat and in the best of condition. Upon inquiry I find that the above as well as blackbirds and others had not been away at all.

Opposite the little city of Vermillion—where the university is located—the flood plain of the Missouri River is from four to ten miles wide. In this flood plain region there are a number of thickly wooded islands and small land areas, where trees and bushes with wild grape vines are abundant. The grapes, ungathered, simply remained on the vines all winter in an excellent condition. In these groves and thickets the birds found all the protection and food necessary when the prairie land was deeply covered with snow and when the thermometer was twenty-five degrees below zero.

Some robins taken in January and others weeks later were said to be stained through and through with the red juice of the wild grapes.

It will be interesting to note whether such birds as the robin, bluebird, blackbird, and others will again remain with us all winter. It will also be worth while to know whether it is common in this latitude for the above birds to fail to migrate to the south, and when they do not go what are the environments where they remain. Do we find the above birds migrating when food is plentiful? Or when the climate is mild?

Would it not be possible for the readers of this magazine, by a little

observation, to answer a number of interesting questions concerning bird movements, of which we are not certain at the present time? Among the simplest of questions to be answered by our own observations are the following:

1. What birds remain as permanent residents in our localities?
2. What birds spend the summer months with us, building nests and raising their young, coming in the spring and leaving us in the fall?
3. What birds stay in our neighborhood during the winter months, coming in the fall and leaving in the spring, but never nesting with us?

When the above problems are solved it will be easy to add other questions concerning the movements of birds, which can be answered by those who love outdoor life and enjoy learning for themselves the secrets and wonders of nature.

OUR BERLIN CORRESPONDENT.

Cauersts II. 11 Charlottenburg, Germany.
November 8, 1905.

My Dear Professor Collins:

At your request I will write a few words in regard to the schools of Germany, but a stay of two months, in which most of the time has been given to other matters, does not permit me to speak with authority. From the first I have been impressed with the social distinctions, and the great influence they must have on the system of education. Every paper I have signed requires my social position or vocation. When registering at a hotel, leasing a flat, matriculating at the university, even when drawing a book at the Royal Library the social position must be given. In the newspaper it is always *Cabdriver* Lehmann, *Painter* Schulz or *Carpenter* Müeller that has been injured in a street accident.

The sons of laborers, trades people and the like go to the common schools where the training is for good citizenship, and at the age of fourteen they leave school to become laborers, trades people and the like. The sons of doctors, lawyers, teachers and government officials and the like enter the higher schools where they are *educated*, and with later university training take those vocations which accord with their social postion.

I have visited a common school and will report briefly what I have learned. More thought is given to these schools than formerly, and they deserve much attention for ninety per cent of the German children attend them. In these schools the pupils are allowed to have only two text-books, a reader and a Bible history. Geography, history, mathematics and nature study are learned in the class room from pictorial charts, maps and drawings. "The teacher teaches"—and on excursions to the Sieges Allee, Tiergarten, museums, parks and so on it is quite a common sight to see thirty or forty boys or girls in charge of teachers on such an excursion. In summer the school session is

from 7 A. M. to 12 M. and in winter from 8 A. M. to 1 P. M., six days in the week. The teachers are permitted to use the rod and according to our notions it is often used with undue severity.

The school I visited in a suburb of Berlin has twelve teachers and seven hundred pupils. From 9:10 A. M. to 10 the rector of the school had a class in mathematics. He spoke in a very loud voice and conducted the recitation with military sharpness. He pointed at the boy who was to answer his question and exclaimed, "You!" When a boy was called to the blackboard the command was, "Come here!" and he was dismissed with an emphatic "Away!" The recitation was largely a review on the names and relations of the angles formed by a line cutting two parallels. The teacher drew the figure on the board and boys named the angles as he pointed to them, or named the pairs of equal angles. No formal demonstrative proofs are given in this course, but axioms were quoted to prove certain pairs of these angles equal, and also to prove that vertical angles are equal. A boy constructed a line parallel to a given line, drew a transversal, and from this figure the pairs of equal angles were named. All the boys had previously made this construction on a sheet of paper, and had cut the paper along one of the parallel lines. At the command of the teacher they held up their drawings toward the windows, and placing one piece of paper on the other, tested the equality of the angles. A boy constructed a line perpendicular to a given line and another measured the angle with a large wooden protractor. At every question of the teacher all hands were raised, but it was evident that some of the boys raised their hands when they did not know the answer and really did not expect to be called on. It was also evident that only the best pupils were called on for the most part, and two or three who were ready with answers were called on many times. Axioms and definitions were repeated in concert by the class in a loud voice, and each word was spoken very distinctly. In fact, in each class I visited much attention was given to correcting errors in speech. Though the rector was brusque the boys did not seem to fear him. The attention was tense when he was addressing them, but there was quite a good deal of whispering at one time when he was drawing a figure on the board. However, when he finished the drawing and rapped fiercely on the desk, saying, "One! two! three!" the boys straightened up, folded their hands on the desk and were all attention again.

In the reading class the teacher read the whole selection slowly and distinctly and then several read the first paragraph. The teacher asked many questions to draw out the meaning and two or three boys gave the story of the paragraph in their own words. One boy recited the ten commandments, and the class recited a poem, and several gave an outline of the poem. All this was review. The whole was largely an exercise in speaking correct German.

The first part of the hour in the class in religion was given to the commandment: "Thou shalt not steal!" The teacher asked many questions to make sure they understood its meaning. The story of Joseph

was told; one boy told of Joseph's dream, another of the selling of Joseph, and so on. At the close of the hour the boys arose, and with bowed heads repeated a prayer in the form of a little poem and were dismissed for the day. The work as I saw it in these classes seemed to be largely a training of the memory. The evil of large classes exists here, but I do not know to what degree. One young lady, a teacher in a Berlin common school, has seventy-three pupils in her room.

There is a strong movement for reform in the educational system, but I am not as yet prepared to speak of it. Among the later books on the subject are the following:

"Die neue Erziehung," Dr. Heinrich Pudor. H. Seeman, Leipzig, 5 M. 1902.

"Wo bleibt die Schulreform?" Dr. Rhenius. Felix Dietrich, Leipzig, 1904.

"Erziehung und Erzieher," Rudolph Lehmann. Weidmann, Berlin, 1901.

"Der Deutsche und sein Vaterland," Dr. Ludwig Gurlitt. 1.50 M. and bound 2.25 M.

"Der Deutsche und seine Schule," Dr. Ludwig Gurlitt. Wiegandt und Grieben, Berlin, 2.00 M., bound 3.00 M. 1905.

Yours very sincerely,

H. E. COBB.

If one may judge from a recent bulletin by Mr. E. Dwight Sanderson, issued by the United States Department of Agriculture, the cotton plant has not only the boll weevil to contend with in its struggle for existence, but a whole army of insect parasites. As soon as a young plant begins to grow, many are destroyed by cut-worms, which nibble off the stems and often render it necessary to replant a considerable area. With the formation of the first true leaves of the cotton, winged plant lice appear in large numbers on the under side of the leaves and on the terminals. Often indeed the buds of the plants are black with them. If it escapes the ravages of the plant lice, the new cotton may fall a prey to the web worm. The larvæ of the white-lined sphinx moth are likewise common pests of cotton fields. Occasionally their numbers are such that they destroy all low-growing vegetation in their path. The differential locust, by far the most injurious grasshopper in Texas, often cripples a cotton field; and in the spring of 1904 young differential locusts just after they had hatched from the eggs destroyed the young cotton to an alarming extent. Two species of wingless May beetles may seriously injure young cotton. The salt marsh caterpillar, which is one of the "woolly bear" caterpillars, and is covered with long black and red hair, is a particularly virulent enemy. It is said that when fully grown it even resists attempts to poison it with Paris green. Still other insects which cotton planters fear are the large tiger moth, the army worm, the fall army worm, the Io moth, the cotton belt cut-worm, the leaf-cutting ant, the cotton-stalk borer, the tree cricket, the cotton square borer, cotton sharp-shooters, leaf-footed plant bugs, click beetles, cowled weevils, acorn weevils, and plaster weevils.—*Sc. Am. Sup.*

A COMMUNICATION.

Ames, Iowa, Feb. 5, 1906.

Dr. G. W. Myers,
University of Chicago.

Dear Sir:—

Your treatment of logarithms for secondary schools seems to me to be just the thing that is needed. It seems to leave nothing more to be desired. I have been in the habit of patching up the ordinary text by the following original method of an approximate calculation of the logarithms of whole numbers up to ten. After your method this is a back number.

Let log. $2 = x$, then log. $5 = 1 - x$, log. $128 = 7x$ and log. $125 = 3 - 3x$. Let us make three successive approximations which we will call I, II, III.

I. $7x = 3 - 3x$, giving $x = .3$.

II. log. $64 = 6x$, $128 = 7x$, interpolating, log. $125 = 6.95x = 3 - 3x$, $x = .301$.

III. That the interpolation may be more nearly exact we seek a number but little less than 125, log. $(64)2^{\frac{15}{16}} = 6.9375x$, *i. e.*, log. $122.5728 = 6.9375x$.

Interpolating, log. $125 = 6.9654x = 3 - 3x$, giving, $x = .3010$.

We put log. $3 = y$ and use 80 and 81 in I, II, and III as above.

Then we take log. $7 = z$ and use 50 and 49.

Respectfully,
T. M. BLAKSLEE.

PROFESSOR BLAKSLEE'S "PROOF."

On page 136 of SCHOOL SCIENCE AND MATHEMATICS for February, Prof. Blakslee offers the following proof to supply the hiatus in Euclid I. 16.

"Proof. The ray of the median has cut both of these rays [side of triangle and side produced] at once. *The join of the vertex of an angle with a joint within the angle lies within the angle.* [Italics mine.] $\therefore <$ from base to join, $< \llcorner$ from base to side."

Is the statement—the join of the vertex, etc.—an axiom or a theorem? I fail to find it under either head in Euclid. It reads to me exactly like the axiom I said was needed.

Of course, as a matter of pedagogy this is hypercriticism; my former article was to show the unpedagogical character of such hypercriticism by a *tu quoque*. As a matter of exact logic it is not hypercriticism. The gap is there; easily filled to be sure, but nevertheless existent, regardless of which head, axiom or theorem, the statement falls under when supplied. Prof. Blakslee has violated the excellent admonition laid down by Prof. Lennes on p. 744 (December, 1905, SCHOOL SCIENCE AND MATHEMATICS) about not letting new assumptions creep in under the guise of "obviously." ARTHUR LATHAM BAKER.

PROFESSOR LYTLE'S "DEFINITION OF A LIMIT."

On page 35 of the January SCHOOL SCIENCE AND MATHEMATICS Professor Lytle accuses me of selecting a bad definition of limit, etc. He has overlooked the fact that I was not *defining* a limit. I took the definition we find in the geometries and undertook to show that since geometric forms do not necessarily have limits as there defined, they are of "very little importance to the teachers of elementary mathematics" (Prof. Lytle, p. 40). Most of Professor Lytle's article is taken up with limits of algebraic forms, with which my article had nothing to do; and for algebraic forms he is undoubtedly right that the limit is an intrinsic property of the form. He seems to have overlooked the fact that I was aiming entirely at geometric forms and their *limits as defined in the geometries*, a definition illustrated by the expression $x = +\frac{1}{2} + \frac{1}{4} + \;\ldots\ldots\frac{1}{2n} = 2 - \frac{1}{2n}$ where 2 is defined as the limit of x, a value which x can be made to approach indefinitely near, but which it always falls short of by $\frac{1}{2n}$.

On page 36 he says the angle x (between the two lines) is not the same when generated by the movement of the point A as when generated by the movement of the point B, since the two cases do not run through the same sequence of values. Isn't it rather a fine distinction to say that a piece of elastic is not the same piece when stretched by two different laws; that an angle between the clockhands generated by one law is not an angle when generated by some other law? Has he not confused quality and quantity? I was speaking of qualitative variables. It was the qualitative variable X which was under discussion. Generated by the movement of B it runs through a certain set of values; generated by the movement of A it runs through exactly the same set in exactly the same order and then through others beyond.

On page 40 he says, "We cannot recall a single branch of mathematics which makes any use of the limit of a geometric form." How about the incommensurable cases in central angles are measured by the intercepted ones; in a line parallel to the base of a triangle cuts the sides proportionally; in rectangles having the same altitude are to each other as their bases; and in the circle is the limit of the inscribed polygon; the area of a circle equals πR^2, etc., in geometry?

He has also overlooked the fact that the definition of axiom to which he objects in my article is not mine but that of the author of the article which I was criticising, on whose platform I stood for the time being. ARTHUR LATHAM BAKER.

NOTES FROM THE UNIVERSITY OF ILLINOIS.

The Mathematical Club has elected the following officers for the second quarter: President, Miss Jessie J. Bullock; Vice-president, Mr. T. L. Kelley; Secretary and Treasurer, Mr. E. H. Fath.

The following papers have been recently presented to the Mathematical Club:

"Some Psychological Aspects of Mathematics," by Dr. S. S. Colvin, Associate Professor of Psychology.

"Core Sections as Applied to the Theory of Beams," by Dr. S. E. Slocum, Assistant Professor of Mathematics.

"The Theory of the Leyden Jar," by Dr. C. T. Knipp, Assistant Professor of Physics.

"Report of the November Meeting of the Central Association of Science and Mathematics Teachers," by Miss Jessie J. Bullock.

"Report of the December Meeting of the Chicago Section of the American Mathematical Society," by Dr. L. I. Neikirk, Instructor in Mathematics.

"Method of Calculating the Height of Birds by the Observation of their Flight Across the Moon's Disc," by Dr. Joel Stebbins, Assistant Professor of Astronomy.

The Illinois Chapter of Sigma Xi held a scientific meeting on the evening of December 18, at which Prof. Morgan Brooks gave an illustrated talk on "Transformers." Later refreshments were served.

Acting Dean E. J. Townsend has been elected a member of the Council of the American Mathematical Society.

Mr. James Harvey Dickey, '98, is instructor in mathematics in the Millikin University, Decatur, Ill.

Miss Neta Hannum, '05, is instructor in mathematics in the Litchfield (Ill.) High School.

Miss Nella W. Reese, '05, is instructor in mathematics in the Paxton (Ill.) High School.

Mr. Noah Knapp, '04, is instructor in mathematics in the Oak Park (Ill.) High School.

Mr. Harry W. Reddick, until February first, Fellow in Mathematics in the University of Illinois, is now teaching mathematics in the Shortridge High School at Indianapolis, Indiana.

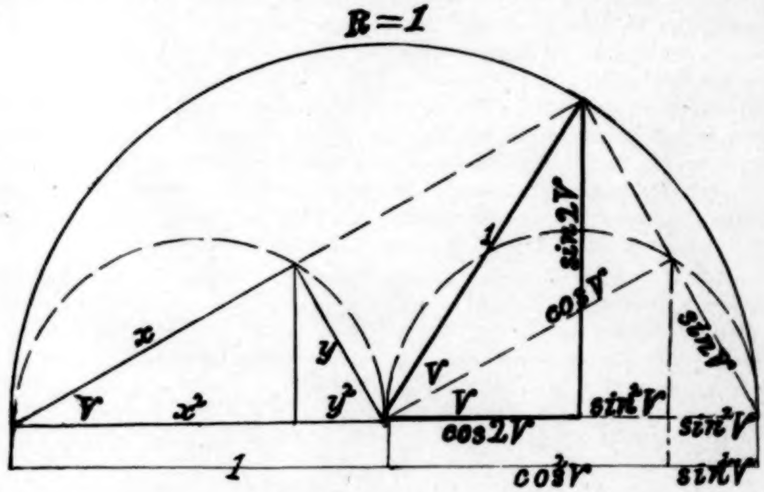
ERNEST B. LYTLE.

In the *American Naturalist* for December is also a valuable contribution on "Forest Centers of Eastern America" by Dr. E. N. Trauseau. He finds that there are in Eastern North America four great forest centers: (1) the Northeastern Conifer forest, centering in the St. Lawrence basin; (2) the Deciduous forest, centering in the lower Ohio basin and Piedmont plateau; (3) the Southeastern Conifer forest, centering in the South Atlantic and Gulf coastal plain, and (4) Insular Tropical forest of the southern part of the Florida peninsula, centering in the West Indies. In this division the regions where the forms reach their best development are indicated by the term center. This region is not necessarily stable, but varies in response to continental and climatic changes. The factors that have most influence in determining distribution are temperaure, relative humidity, wind velocity, and rainfall.

NOTE.

The enclosed figure has seemed to me quite rich in the number of geometry formulas that may be directly read from it. Especially the half angle formulas. While I would not recommend it as in any way a substitute for the usual methods, it might interest some.

T. M. BLAKSLEE.



In the *American Naturalist* for December, 1905, is an article of special interest to both zoologists and botanists—"Ecology of the Willow Cone Gall," by R. L. Heindel. It was known already that this gall is the home of quite a number of insects, but the present work reports additional observations on the number of species that inhabit the cone gall as well as giving many interesting facts regarding their habits within the gall. The author finds "at least thirty-two species of insects making use of the cone galls. Of these, one is a gall maker, ten are inquilines, sixteen are parasites or hyperparasites, and five are transient or accidental guests." In connection with the fact that eggs of the meadow grasshopper were found in both young and old galls, reference is made to Wheeler's belief "that this insect's habit of putting its eggs in the galls is of comparatively recent acquisition because in some cases the eggs are poorly placed and because insects still use galls whose scales are so close together as to flatten and kill the egg, evidence that the grasshopper has not learned to distinguish the kind of gall best adapted to its purpose. If we accept Wheeler's conclusion, we may say that the gall is of increasing importance to the insect world."

DEPARTMENT OF ZOOLOGY.

A Guide to the Protozoa.—Bulletin No. 2 of the Connecticut State Geological and Natural History Survey has recently appeared. It is by Professor H. W. Conn and is entitled: A Preliminary Report on the Protozoa of the Fresh Waters of Connecticut. It contains 69 pages of text and 34 plates with 303 figures. The major part of the text is devoted to a key to genera of the fresh water Protozoa and the figures, which are mostly very good, illustrate the species found by the author in Connecticut.

The more common species of Protozoa are so widely distributed that this key is as useful in the Mississippi Valley as in Connecticut, and it is by far the best guide for the identification of these animals that is available to most teachers in secondary schools. While the edition lasts it can be obtained by teachers from Mr. Geo. S. Godard, State Librarian, Hartford, Conn., for thirty-five cents.

An Unusual Number of Snowy Owls.—An article in the *Auk* for January, 1906, calls attention to the appearance of an unusually large number of these birds this winter. Two taxidermists in Chicago had received twenty-eight specimens at the time the article was written, and another in Boston reported that he had received twenty. Reports of others seen by various naturalists are noted.

Five specimens have been taken in the region about Urbana, Ill., of which one was killed within the city limits.

Horned Larks, Grouse, and Wild Turkeys.—Bulletins 23 and 24 of the Biological Survey, Department of Agriculture, deal with the food and economic relations of these groups of birds in the United States. No. 23 contains a plate showing a group of horned larks and No. 24 plates showing the ruffed grouse and sage grouse. The quails were similarly treated in Bulletin No. 21.

Bird-Lore for November-December, 1905, has three colored plates of birds, of which two are in continuation of the warbler series and the third shows the American goldfinch, male and female. The management promises that hereafter, in addition to the warbler plates, each number of *Bird-Lore* shall contain a colored plate of the male and female of some well known North American bird. To teachers who subscribe to *Bird-Lore* opportunities are offered for obtaining extra copies of the colored plates.

Lateral-line Organs.—Professor G. H. Parker, of Harvard, has published in the Bulletin of the Bureau of Fisheries for 1904 (Washington, 1905) a paper on the function of the lateral-line organs in fishes. His experiments show that these organs occupy a place intermediate between the touch organs of the general integument and the ear, being stimulated by water vibrations of low frequency—six per second. There was no evidence of stimulations by light, heat, salinity of water, food, oxygen, carbon dioxide, foulness of water, water pressure, water currents or sound.

Reactions of Earthworms to Light.—It is well known that earth-

worms move away from light of ordinary intensity, that is, they are negatively phototropic, although toward very dim light, as has been shown by G. P. Adams in the American Journal of Physiology, Vol. 9, 1903, they are positive. The question of the nature of this negative response, whether a definite orientation or "tropism" or a selection of random movements, has been raised by S. J. Holmes in the Journal of Comparative Neurology and Psychology, Vol. 15, 1905. The author supports the latter view. In the December, 1905, number of the Biological Bulletin E. H. Harper writes on the reactions of the earthworm, *Perichæta bermudensis*, to light and mechanical stimuli, and gives evidence to show that in strong light negative phototropism manifests itself by a direct, continuous reaction, while in light of lower intensity random movements often occur. He also points out that the worm is more sensitive in an extended than in a contracted condition, and discusses the relation of these experimentally derived facts to the habits of earthworms in their burrows.

REPORTS OF MEETINGS.

PACIFIC COAST ASSOCIATION OF CHEMISTRY AND PHYSICS TEACHERS.

At its winter meeting at Berkeley the Pacific Coast Association of Chemistry and Physics Teachers voted to adopt SCHOOL SCIENCE AND MATHEMATICS as its official organ. By this arrangement members of the association will be able to obtain a monthly magazine containing a record not only of the proceedings of the Pacific Coast Association, but of other like organizations in all parts of the country. But in order to effect this very desirable improvement it is necessary that at least fifty names be at once sent to the editor of SCHOOL SCIENCE AND MATHEMATICS. Members who have not paid the increased dues, and all persons wishing to become members of the association are earnestly requested to act in this matter without delay in order that a full list of names may be sent off at once and the subscription to the magazine begun with the January number.

The Association of Chemistry and Physics Teachers is stronger now than ever before and is increasing every day in membership and influence. Its recent meetings at Berkeley, where it had control of the science department work of the California Teachers' convention, were the most interesting and instructive ever held in this state. Its object is to encourage and forward the teaching, not only of chemistry and physics, but of all science in the public schools of California, and in the half dozen years of its existence it has done much good work in this direction. All persons interested in this matter, whether teachers of chemistry or physics or not, are eligible to membership. Persons wishing to join the Association should send their names and mailing addresses to the Secretary, Edward Booth, Chemistry Department, University of California, Berkeley, together with $1.25, the annual dues. No other formality is needed.

The advantages of membership are:

First:—It brings members in contact and communication with others of like ideas and aims and enables them to exert on educational methods an influence impossible from individuals. It makes them a power in educational circles.

Second:—It brings them together two or three times a year to consult and discuss the problems that arise in their practical work.

Third:—It gives them the leading school magazine of the country at a price but a trifle more than half what it would cost them if they subscribed for it directly.

Dues paid now ($1.25) will give membership until January 1st, 1907. The former dues ($1.00) which have already been paid will extend membership until the same date when an additional twenty-five cents is paid. The attention of members who have paid the $1.00 dues is especially called to this extension of time and they are requested to send the additional amount at once so that their names may be placed on the subscription list without delay.

By adopting School Science and Mathematics as its official organ, the Association does not in any manney alter the character of its work. With enlarged membership, it will take an even more prominent part in educational matters. Its recent meetings at Berkeley give earnest of this. The proceedings of these meetings will be published in full in the near future in the official magazine. The first meeting, December 26th, was devoted to a consideration of the teaching of theory in chemistry. Two able papers were presented, one by M. S. Baker of the Lowell High School, of San Francisco, and the other by Roy Fryer of Sacramento. The discussion following the reading of the papers was led by Dr. F. G. Cottrell, of the Chemistry Department of the University of California, and developed the fact that while those present were unanimous in believing that chemistry can not be taught without considerable attention being paid to theory, yet much difference of opinion exists as to the amount that should be taught and the emphasis that should be given to it.

The afternoon of December 28th was devoted to physics. S. E. Coleman of the Oakland High School read an able paper, giving his views as to how the subject of energy should be presented to high school students. Incidentally he criticised in a rather caustic manner the books written by Professors Sanford and Slate. As Professor Sanford led the following discussion and Professor Slate was represented by Dr. Arthur Gray of the Physics Department of the University the discussion took a somewhat personal and decidedly interesting turn. The second paper of the session, by Lewis B. Avery, on "Proposed Improvements in the teaching of Physics," caused a most interesting discussion. The speaker, after calling attention to the unpopularity of the subject, told of an experiment in the Redlands School where an interesting non-mathematical, non-technical course was given as an introduction to the more technical course. The experiment had been a complete success. He made a strong plea for more latitude for the high schools in the matter of University requirements so that such

experiments might become a possibility and the methods of teaching be correspondingly improved. As a result of these suggestions and of the discussion which followed, the President was authorized to appoint a committee to endeavor to effect the changes asked for.

EDWARD BOOTH,
Secretary-Treasurer.

NOTES FROM THE NEW YORK STATE SCIENCE TEACHERS ASSOCIATION

At their recent meeting, held in Syracuse, a resolution was introduced and passed, heartily encouraging the proposed biological survey of the state by the officials of the state department. Dr. C. W. Dodge of the University of Rochester was appointed chairman of a committee to aid in carrying out the project.

The Association also passed a motion favoring the passage of the bill now pending before Congress favoring the adoption of the metric system.

REPORT OF THE MEETING OF THE ASSOCIATION OF TEACHERS IN MATHEMATICS IN WASHINGTON.

The regular annual meeting of the Association was held on December 29 at North Yakima. The following program was rendered:

Preliminary Report on a Proposed Text of High School Mathematics. —Prof. Robert E. Moritz, University of Washington.

Present Day Defects in the Teaching of Secondary Mathematics.—Professor J. C. Keith, Seattle High School.

The Relation of Mathematics to Applied Science.—Prof. O. L. Waller, Washington State College.

A Comparison of Some Definitions with Reference to the Derivation of Operations from Them.—Prof. W. A. Bratton, Whitman College.

Mathemates in the High School: Its Subject Matter and Methods.—Prof. J. L. Dunn, Spokane High School.

The following officers were elected for the ensuing year: President, Prof. Robert E. Moritz, University of Washington; Vice-president, Prof. J. C. Keith, Seattle High School; Secretary-Treasurer, Miss Zella E. Bisbee, North Yakima High School.

A good, live meeting was held and much interest was manifested. It takes time to get things started here but the teachers have taken hold of the work better than I expected. A larger number also are getting interested in SCHOOL SCIENCE AND MATHEMATICS.

J. E. GOULD.

THE MISSOURI SOCIETY OF TEACHERS OF MATHEMATICS (AND SCIENCE).*

The Missouri Society of Teachers of Mathematics (and Science) met in Jefferson City, December 27 and 28, 1905, in conjunction with the State Teachers' Association. Two afternoon sessions were held and

*See proposed amendments to the constitution.

were well attended. The first session was called to order by the president, H. C. Harvey, and the Society proceeded at once with the program.

Professor George R. Dean of Rolla presented a paper on "Maxima and Minima." He suggested an elementary treatment of those problems which occur in elementary geometry by a simple process which can be made accurate. Noting that on each side of a maximum there are corresponding points for which the value of the dependent variable are equal, he suggests that the correct solutions of many elementary problems may be found as the common limit of two equal values of the dependent variable. For example, the largest rectangle inscriptible in a quadrant of a circle *is the square,* since there are evidently equal rectangles which approach the square as their common limit. Several other simple applications were given.

Dr. Oliver Glenn, of Springfield, Mo., presented a paper on "Laboratory Methods in Algebra Teaching." He pointed out the fact that many parts of the science of algebra had been reduced to barren formalism by our modern teaching, by divorcing it from the geometric and physical phases which belong to it historically. He described the need of a laboratory or verifying agency, and reported the result of some of the work of his own freshman classes, where one hour per week has been devoted to work with drawing instruments.

In the discussion, Dr. Hedrick emphasized the importance of the use of cross section paper as a tool, co-ordinate with the ruler and compass. Mr. Butler related an experiment made in two sections of physics, one of which used cross section paper while the other did not. He found that the class which used the cross section paper made much better progress and achieved much better results than the other. Mr. Ginnings emphasized the importance of the students acquiring two view points, the analytic and the geometric. He favored giving the two view points at the same time and proposed that "elementary mathematics" should replace the teaching of algebra and geometry. Mr. Harvey said he uses graphical work to supplement the analytical work which should receive the chief emphasis. Many students can be interested in the graphical presentation who could not be interested in the analytical. Dr. Hedrick suggested that the changes in methods should not be too revolutionary; try a little and profit by experience. Miss Lowen said she had tried graphical work in the high school and found it very successful.

Mr. A. M. Wilson of St. Louis presented a paper on "The Treatment of Limits in Elementary Geometry." Mr. Wilson emphasized the difficulty in the treatment of limits in high school work, which has been the subject of recent discussion in SCHOOL SCIENCE AND MATHEMATICS. The incommensurable cases in geometry; the so-called proofs of the statement that the area of a circle is the limit of certain polygons, and other allied propositions were characterized as difficult for the pupil, and sometimes worse than useless as presented in current text-books; and the suggestion was made that it is perfectly justifiable to make assumptions—without proof—when necessary, in order at once to avoid meaningless and incorrect proofs and to give the

student the fundamental conceptions of the notion of a limit. Dr. Ames, following the same line of thought, emphasized the importance of frankness and honesty in such matters. A fundamental characteristic of the scientific spirit is willingness to acknowledge frankly the fact whenever a statement is not rigorously proven, and only a blunting of the student's appreciation of the scientific spirit can result from surreptitiously introducing assumptions under the guise of logical treatment. Particular points may be presented rigorously in the high school, but not the whole of geometry. Dr. Hedrick suggested that we omit from the high school course all treatment of limits except simpler illustrations, since a rigorous treatment is impossible and absurd at that stage of advancement.

The second session was devoted to a general round table discussion of the subject, "What Should Be Taught in Arithmetic and What Omitted."

Mr. Jaudon urged in a short paper the absurdities of some of the present arithmetic teaching. Mr. U. S. Hall presented some results of systematic drill in oral arithmetic. Professor Harvey opened the real discussion of the proper topics for elementary arithmetic. He suggested the introduction of graphical work of a simple character, even in arithmetic. To offset this and give room for still other matter, he suggested the omission of such topics as compound proportion, cube root, and other matter of a complicated nature. In the absence of the others directly following Professor Harvey on the program, the paper was discussed by Superintendent Longan and H. H. Holmes of Kansas City and others.

The last paper on he program was by Dr. Hedrick who definitely proposed certain changes for consideration, as follows: The omission of the topics, cube root, and allied forms, G. C. D. and L. C. M., by the traditional "division" or Euclidean method; a large amount of the pseudo-business methods in so far as they are not real; and the treatment of complicated "practical" examples which are essentially examples in algebra. For insertion were suggested the graphical representation of tables of prices, statistics, and so on, leading up to the graphs of algebra; observational geometry as an expansion of the traditional work on mensuration; and the most elementary concepts of algebra, including the solution of simple examples in linear equations. It was insisted that the only justification of any topic was either its direct usefulness, its beauty, or its interest to the pupil from some standpoint, and that the disciplinary value was not a sufficient ground for including any topic, in view of the wealth of material which has this virtue along with others. The fact that many problems usually solved in arithmetic actually employ the word "something" or an equivalent as a symbol for the unknown was pointed out and the absurdity of these solutions which are professedly non-algebraic but really precisely algebraic was urged as a final argument for the exclusion of excessively intricate examples and the inclusion of elementary algebra.

At a business meeting held to consider the enlargement of the Missouri Society of Teachers of Mathematics so as to include teachers

of Science, Mr. W. J. S. Bryan of St. Louis was asked to take the chair. An informal report was made by Dr. Hedrick concerning the meeting in conjunction with the National Educational Association at Asbury Park called for the purpose of considering the formation of a National Society. It was explained that no invitation to join the new society had reached us on account of the delay in settling details

. The following resolutions were adopted by the Executive Council in its session in the evening:

RESOLUTIONS.

Whereas: The formation of an American Society of Teachers of Mathematics and the Natural Sciences was considered by delegates from representative societies in the duly advertised conferences at Asbury Park, and is now under consideration by a duly authorized committee; and

Whereas: The successful formation of some national body seems imminent to control, under due representation, the interrelations of existing societies; and

Whereas: The Missouri Society of Teachers of Mathematics (and Science) has assumed justly its representation of Missouri teachers, and has been recognized as the only competent representatives of such teachers:

Therefore be it resolved:

1. That the Missouri Society intends to affiliate itself with any duly authorized national body of teachers of Mathematics and Science;

2. That the Missouri Society will co-operate with other societies on an equal footing, and will accept the results of any conference in which the Society has had due representation after notice of the proposed conference, but otherwise the Society will not be bound;

3. The territory of the Society is the State of Missouri, and this territory is not recognized as the proper territory of any similar organization without the consent of the Society;

4. Believing the purposes of any society of teachers should be solely to advance the interests of teaching, the Society believes that the best results in this State can be attained by meetings in this State, since most of the members cannot attend meetings elsewhere;

5. Any general Society formed to include the Missouri Society should have set meetings—if at all—near the center of the region covered.

PROPOSED AMENDMENTS TO THE CONSTITUTION.

1. For the insertion of the words "and Science" after the word "Mathematics" at all points in the present constitution, including the title;

2. For the creation of a vice-president of the Society for each of two Sections: (a) Mathematics, (b) Science. These vice-presidents shall act as chairmen in their Sections in the absence of the president, it being understood that meetings will be arranged by the Council, as provided in the Constitution, so that the majority of the time shall be spent in separate meetings, though short joint meetings shall also occur;

3. For the increase of the number of members in the Council to ten, at least four of whom shall be teachers of Science and at least four of whom shall be teachers of Mathematics;

4. The vice-presidents provided for above; and also the chairmen of any local sections authorized by the Council shall be ex-officio members of the Council; and the President shall be ex-officio a life member of the Council.

These amendments will be duly submitted to the members according to the Constitution before the April meeting and arrangements for ballot made.

IOWA STATE TEACHERS' ASSOCIATION, DES MOINES, IOWA.

Mathematics Round Table, Wednesday, December 27, 2:00 P. M., West High School Building, Room 57.

Leader—W. A. Cruisinberry, Des Moines.

Secretary—

"The Mathematical Course for High Schools."—Professor W. Lee Jordan, Burlington High School.

"An Investigation of High School Mathematics as a Preparation for College."—Professor Maria M. Roberts, Iowa State College.

"Practical Astronomy with the Equatorial, and its Accessories."—Professor D. W. Morehouse, Drake University.

"The Laboratory Method in the Teaching of Geometry."—Professor D. Sands Wright, Iowa State Normal.

"Teaching Mathematics vs. Teaching a Text-Book."—Professor W. J. Rusk.

Program carried out in full as above.

The following business was transacted:

A committee to report upon a practical course of study in mathematics for high schools, at next year's meeting, was appointed. The members of this committee are Principal W. A. Crusinberry, West Des Moines High School, chosen by vote of the Round Table, and Professor D. Sands Wright, Iowa State Normal School, Professor W. J. Rusk, Iowa College, Grinnell, appointed by the chair.

Officers were chosen for next year as follows: Chairman, Professor W. J. Rusk, Iowa College; Secretary, Miss Martha A. Beeson, West Des Moines High School.

The newly elected officers were made a committee to take steps toward the affiliation of this Round Table with the Central Association of Science and Mathematics Teachers.

IRA S. CONDIT, Sec. pro tem.

MATHEMATICS SECTION OF THE INDIANA STATE TEACHERS' ASSOCIATION.

The annual meeting of the Mathematics Section of the Indiana State Teachers' Association was held at Indianapolis, December 27, with about 250 teachers of mathematics present. The following papers were read: (1) "The High School's Portion of Higher Mathematics," by Professor D. H. Rothrock of Indiana University; (2) "Teaching vs.

Instructing," by Professor John C. Stone of Ypsilanti; (3) "In What Grades Should the Study of Algebra Begin?" by Supt. Geo. L. Roberts of Muncie; (4) "How can High School Mathematics Better Prepare for the Study of Science?" by Leonard Young of Evansville High School.

The Mathematics Section expressed its approval of the organization of the teachers of mathematics into a State Association of Mathematics Teachers, and a committee of five was appointed to arrange for a preliminary meeting to perfect an organization. The committee consists of Professor D. H. Rothrock, Indiana University, Bloomington; Professor T. G. Alford, Purdue University, Lafayette; Professor W. P. Morgan, Stae Normal, Terre Haute; Principal D. R. Ellabarger, High School, Richmond; Mr. G. H. Mingle, High School, Anderson.

The Committee will call a meeting of the proposed Association to meet at Indianapolis on March 30, in connection with the spring meeting of the Southern Indiana Teachers' Association.

NEW ENGLAND ASSOCIATION OF CHEMISTRY TEACHERS.

The twenty-fourth meeting was held at Harvard University Saturday, November 18, 1905. It was also the annual meeting. Reports were read by the Secretary, Harold Bisbee, and the Treasurer, E. F. Holden, revealing the flourishing condition of the Association. The membership increases every year and is now 111, exclusive of those who were elected at this meeting. About half of the members are active. The following were elected members:

Active—Matthew P. Adams, State Normal School, New Britain, Conn.; Miss Cora A. Durgin, South High School, Worcester, Mass.; Walter E. MacGowan, High School, Attleboro, Mass.; William W. Obear, High School, Fitchburg, Mass.; Louis H. Levy, Technical High School, Providence, R. I.; Miner H. Paddock, Technical High School, Providence, R. I.; Wilhelm Segerblom, Phillips Exeter Academy, Exeter, N. H.

Associate—Dr. L. D. Bissell, St. Paul's School, Concord, N. H.; Miss Mary A. Hird, High School, Beverly, Mass.

The following officers were elected for the year 1905-6:—

President—Albert S. Perkins, High School, Dorchester, Mass.

Vice-president—Sidney Peterson, High School, Brighton, Mass.

Secretary—Harold Bisbee, High School, Dorchester, Mass.

Treasurer—Edward F. Holden, High School, Charlestown, Mass.

Executive Committee—The above officers and Miss Laura B. White, Girls' High School, Boston, Mass.; Henry P. Talbot, Institute of Technology, Boston, Mass.; Lyman C. Newell, Boston University, Boston, Mass.

The guest and speaker was Professor Wilhelm Otswald of Leipzig, Germany, who is lecturing at Harvard University this semester. He spoke on "The Place of Modern Ideas in Physical and Theoretical Chemistry in the High School Course of Study." The speaker said that much of what he believed about elementary teaching was published in a little

book called "Conversations in Chemistry." He laid emphasis on the fundamental and simple character of the law of phases and the ease with which it may be introduced into elementary teaching. He also stated that the law of combining weights can be developed without using the term atom or even referring to the atomic theory. Regarding ions he brought out one excellent point, viz.: that an ion in elementary teaching can easily be spoken of as an independent part of an acid, base, or salt in solution, irrespective of the electrical relations which may be subsequently developed in the class.

Professor Ostwald was made an honorary member of the Association.

L. C. N.

ASSOCIATION OF OHIO TEACHERS OF MATHEMATICS AND SCIENCE.

The Association of Ohio Teachers of Mathematics and Science held its third annual meeting in Townshend Hall, Ohio State University, Columbus.

The following program was carried out:

Mathematics Section.

1. Do the mathematical courses in literary colleges properly fit for the mathematics of engineering? Christian Hornung, Tiffin. 2. Sir Isaac Newton—an estimate. C. L. Arnold, Columbus. 3. Report of the committee on "A straight line is the shortest distance or path between two points." George Bruce Halsted, Gambier. 4. A preliminary report of the committee on a syllabus of the fundamental propositions of elementary geometery proposed for consideration by the Association of Mathematical Teachers in New England, George Bruce Halsted, Gambier. 5. Symbolism in Mathematics, Harriet E. Glazier, Oxford. 6. A contribution from non-Euclidean geometry to school spherics, George Bruce Halsted. 7. The influence of college entrance certificates on the teaching of mathematics in the high school, Harry E. Giles, Kenton.

Science Section.

1. To what extent should industrial applications be included in the elementary courses in physics and chemistry? George R. Twiss, Cleveland. 2. Should chemistry be a required study for entrance to colleges? Clinton G. Stewart, Toledo. 3. Should more than one year be given to the study of any one science in the high school? T. Otto Williams, Circleville. 4. To what extent, if any, should the theory of electrolytic dissociation be included in the elementary course of chemistry? W. F. Monfort, Marietta. 5. Should quantitative experiments be included in the high school laboratory course in chemistry, and if so, to what extent? W. W. Parmenter, Steubenville. 6. Some essentials for the equipment of the high school laboratory, E. A. Barnes, Geneva. 7. What course in chemistry shall be given in the freshman year to those students who have had chemistry in the secondary schools? Raymond M. Hughes, Oxford. 8. Elementary Science—Its nature and its place in the curriculum of the public schools, Stella S. Wilson, Columbus. 9. The high school course in biology, Edwin P. Durrant,

Westerville. 10. Some demonstrations of the theory of color, Prof. Benjamin F. Thomas, Columbus.

In the afternoon session the two sections met jointly with the Ohio Academy of Sciences and the Ohio State Association of Secondary Teachers for the consideration of topics 8, 9, 10, in the program of the Science Section.

It being the sense of the Association that but one meeting a year should be held, it was decided to elect at this meeting officers for the following year. They are: President, W. H. Wilson, Wooster University, Wooster; Vice-president, T. Otto Williams, High School, Circleville; Secretary, Thomas E. McKinney, Marietta.

A report of the conference at Asbury Park, July 6, 1905, to consider the advisability of forming a National Association of Teachers of Mathematics was presented to the Association; also, a resolution adopted by the Central Association of Science and Mathematics Teachers adopted at its meeting December 2, 1905, and communicated by the Secretary. The resolution and report were referred to the Council for such action as it might deem best.

The appointment of an Assistant Secretary was authorized. Professor M. E. Graber, Heidelberg University, Tiffin, has been appointed to the position. THOMAS E. McKINNEY, Sec'y.

AMERICAN MATHEMATICAL SOCIETY—SAN FRANCISCO SECTION.

A regular meeting of this Section was held on Saturday, February 24. The first session opened at 11 A. M., in Room 50, Quadrangle, Stanford University. The second session was held at 2 P. M. The meeting was unusually successful. The program committee is as follows: E. J. Wilczynski, D. N. Lehmer, G. A. Miller, Secretary, Stanford University, Cal.

BOOK REVIEWS.

Vertebrate Zoology. By Henry Sherring Pratt, Ph. D., Professor of Biology at Haverford College. Ginn & Co., Boston, Mass. 14×20.5 cm., X + 299 pp. List price $1.50.

This is a companion volume to *Invertebrate Zoology* by the same author and publishers. It is a guide to the dissection and comparative anatomy of seven vertebrates commonly used in colleges and high schools. About thirty pages each are devoted to the dogfish (shark), perch, necturus, frog, and turtle, forty-five pages to the pigeon, and sixty-eight pages to the cat. Helpful suggestions are given for the preparation and preservation of material, and the directions are sufficiently detailed and definite to enable the student to proceed with little waste of time or material, and yet there is an abundance of work outlined that will demand painstaking effort on the part of the pupil. The arrangement of the directions will readily permit the omission of such animals or organs as may be thought advisable.

It is the opinion of the reviewer that the book is adapted to a kind of zoological instruction that is more appropriate to the college than to most secondary schools, but the teacher in such schools should find the book especially helpful and no doubt it will often fill an important place in meeting the needs of some pupils in secondary schools.

The book is well gotten up and the matter contained is well selected and accurate.

A Decade of Civic Development. By Charles Zueblin. Two hundred pages, illustrated, 12 mo. Cloth, net, $1.25; postpaid, $1.35. The University of Chicago Press.

A vigorous optimist is in himself a hopeful sign of the times. Professor Charles Zueblin is a man of this stamp. "The last decade," he says, "has witnessed not only a greater development of civic improvement than any former decade, but a more marked advance than all the previous history of the United States can show." Professor Zueblin is a practical man, and his book is a practical book. It gives a concise and spirited account of certain definite measures (economic, political, social, and artistic) for the betterment of American cities.

The author sketches the "culture history" of the nation since the Civil War—the industrial expansion, vast but without order; the gradual change of ideas from theological and individualistic in the '70's to ethical and social at the end of the century; the rise of secular altruism; the influence of Henry George, of the Knights of Labor of England. How science and industry are being made to meet in technical education; how the schoolhouse is becoming a social center; how cities are learning to avail themselves of topographical advantages and avoid the ugliness of disorder; how parks are being extended and business streets improved, and much more. Then taking up the four cities that have been most progressive—Boston, New York, Harrisburg, and Washington—he tells what each has accomplished in the way of self-betterment in the past ten years. He selects a few spectacular instances. But the reader, wherever he may live, will recognize that these are the types of a general movement in which he himself partakes or would like to partake. Indeed, there could hardly be imagined a more effective method of preaching the new crusade than this straightforward recital of what has already been achieved.

The "Civic Renascence" is shown to be a great national movement, comparable to the Civil War and the Reconstruction.

The Open Court Publishing Co. announce a new installment of portraits of eminent mathematicians. As with the first installment, so also with this, the portraits are issued either in a "plate" paper edition 11x14 or in "Imperial Japanese Vellum" 11x14. The first is supplied postpaid for $3.00 and the second for $5.00, remittance to accompany order.

Some of the persons announced to be included in the second installment are Cavalieri, Johann and Jacob Bernoulli, Pascal, l'Hopital, Barrow, Lagrange, Euler, Laplace, Monge and Gauss. It is stated that this

list is tentative and subject to change in case a demand is made for other portraits instead of these.

Those who have had the first set of portraits and used them in teaching will feel that they cannot afford to be without the second set. In issuing these portraits the Open Court Company is rendering a service which merits the coöperation of every teacher and lover of mathematical science. G. W. M.

Laboratory Outlines for General Botany is the title of a booklet written and published by John H. Schaffner, Associate Professor in Botany in the University of Ohio. It is designed "for an elementary study of plant structures and functions from the standpoint of evolution. The outlines are excellently arranged and are calculated to stimulate work by the student rather than to be self-answering questions as are found in some published outlines. A detailed classification of each type that is used is given and the number of types is very large, thus allowing considerable choice of types to fit the flora of a wide range of regions. Diagrams of life-histories are introduced with the more important types. The booklet has stood the test of use in Professor Schaffner's beginning classes, and will be found helpful in a high degree by all teachers of general botany.

BOOKS RECEIVED.

Advanced Algebra. By Arthur Schultze, Assistant Professor of Mathematics at the University of New York and Head of the Mathematical Department, High School of Commerce, New York. Pp. 562, Macmillan Company, New York, $1.25.

Hints and Helps for Young Gardeners. By H. D. Hemenway, Director School of Horticulture, Hartford, Conn. P. 60. Price, 35 cents.

Conversations on Chemistry, First Steps in Chemistry. By W. Ostwald, Professor of Chemistry in the University of Leipzig. Authorized Translation by Stuart K. Turnbull. Part II. The Chemistry of the Most Important Elements and Compounds... John Wiley & Sons, New York, 1906. pp. 373.

The School House, Its Heating and Ventilation. By Joseph A. Moore, Inspector of Public Buildings, State of Massachusetts. 1905. pp. 204.

A Text-Book of Botany for Secondary Schools. By John M. Coulter, A. M., Ph.D., Head of Department of Botany the University of Chicago. D. Appleton & Co., New York. 1906. pp. 365